Report on natural resources for food and agriculture in the Asia and Pacific Region

FAO ENVIRONMENT AND ENERGY PAPER

7

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AND
AGRICULTURE
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FOREWORD

During the past decade, countries of the Asia and Pacific Region have made substantial progress in meeting their food, fuel and fibre needs. However, a growing population is making increasing demands on the natural resources for agriculture, forestry and fisheries. It is therefore vital to conserve the productivity of these resources through rational management and application of appropriate technologies.

This report on the state of natural resources in Asia and the Pacific is an initial attempt to relate natural resources potential and ecological conditions to food and agricultural production in the region. It is intended to update the report periodically, monitor trends and identify emerging issues that can be addressed within FAO's mandate for sustainable use of natural resources.

The report, one in a series covering the various regions, was initiated by the Environment and Energy Programmes Coordinating Centre, Research and Technology Development Division, in cooperation with the Inter-Departmental Working Group on Environment and Energy. Mr. Anil Agarwal, Director of the Centre for Science and Environment (New Delhi) prepared the report, which was edited by Mr. John McCormick and final technical revisions incorporated by Ms Maryam Niamir.

CONTENTS

INTRODUCTION

The developing countries of Asia and the Pacific, together with the Asian Centrally Planned Economies, constitute 70% of the population of all developing countries and over half the world's population. By contrast, they have only 15% of the total land area and about 26% of the land in the developing world. Food production in these countries has actually surpassed global increases. In the 1974-84 decade, the rate of growth of food production was more than 1.5 times the rate of growth of the population (Annex Table 1).

Nevertheless, the race to keep food production ahead of population growth and efforts to improve the nutritional level of people will put increasing pressure on the natural resources of the region. The productive capacity of natural resource for food and agriculture depends on delicate physical and biological balances that are not fully understood. The ability of mankind to disturb these balances has vastly increased. When a resource is used beyond its productive capacity, it becomes degraded and depleted, often beyond the possibility of recovery. Fortunately, modern agricultural approaches and methods are being developed which make production possible on a sustained basis by means of a better understanding of the resilience of the natural resources of various ecosystems.

A global survey of natural resources and the human environment for food and agriculture has already been prepared by FAO. (1) This present report surveys the state of the principal natural resources in the developing countries of Asia and the Pacific and some of the critical problems that have arisen from the growing demands being made on these resources. It draws on information available in FAO and elsewhere. However, because of the lack of reliable recent information, some natural resources have had to be covered in less detail than others. This report is a preliminary survey only, which will require revision and updating as better data become available.

The greater part of the report consists of an overview of the extent, state and potential of natural resources for food and agricultural production (including fisheries and forestry) in the Asia and Pacific Region, and related environmental issues. This is followed by a brief account of specific problems arising from the environmental impact of development activities. As far as possible, the report covers the whole of the developing region. In some cases, however, only a limited amount of information was available. Since the region is very diverse, different sub-regional groupings are used where appropriate.

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(1) FAO, 1980. Natural Resources and the Human Environment for Food and Agriculture. FAO Environment Paper 1. Rome.

1. LAND RESOURCES

1.1 MAJOR SOILS OF THE REGION

Although global soil resources are unevenly distributed, there are probably sufficient available to meet a large expansion in the current world demand for food and agricultural production. But high population density makes the potential for increasing cultivated areas in South and Southeast Asia extremely limited. The needs of the region will have to be met mainly through increased yields on existing cultivated land, making it all the more important to conserve the productivity of the soil.

This report treats the region's soil units at the soil order level. Therefore the suitability of soils for agriculture, forestry and livestock which emerges at the sub-order level, is not covered. Detailed information is available in the FAO/Unesco Soil Map of the World. (1)

About one fourth of the soils of the Asia and Pacific Region have no major fertility limitations but the quality varies widely (see Table 1.1). Soils with no major fertility limitations range from 9% in Singapore to 66% in the Philippines.

Table 1.1 Soil resources of Asia and the Pacific

Soil groupings	Area (million ha)	% of total
Soils with no inherent fertility limitations*	523.9	25.4
Soils with severe fertility limitations	360.7	17.5
Shallow soils	585.1	28.4
Poorly-drained soils	184.1	8.9
Heavy-cracking clay soils	69.7	3.4
Coarse-textured soils	52.9	2.6
Semi-desert and desert soils	172.6	8.4
Salt-affected soils	55.5	2.7
Miscellaneous land units (salt flats, rock debris, snow caps and shifting sand and dune)	58.9	2.7
Total	2 064.2	100.0

Note. The major soil units in the region have been grouped in nine broad categories. For soil units in each category, see Annex Table 2.

* Many of these soils however have slope limitations and are subject to erosion.

Source: Ref. (1).

The main characteristics and distribution of the soils in the region are as follows.

1. Soils with no serious fertility limitations
(Cambisols, Fluvisols, Luvisols, Phaeozems, Nitosols, Podzoluvisols, Kastanozems and Andosols)

These soils are suitable for rainfed crop production, although supplementary irrigation may be needed in the dry season in some areas. Cambisols have considerable intrinsic fertility, but intensive utilization is limited in many areas by topographical features, low fertility, and shallowness, such as the Dystric Cambisols in Northeast China and the Pacific Islands. In such cases, they are suitable for forests and controlled grazing. Cambisols are most common in Asia.

Most Fluvisols are highly utilized for agriculture, particularly for wet paddy. Yields can reach over five tonnes per hectare. However, certain Fluvisols cannot be used for agriculture, e.g. Thionic Fluvisols, which are highly acidic. The most extensive Fluvisols are found in the Mekong and Red River deltas, the central plain of Thailand, the Irrawaddy and Sittan valleys of Burma, and the Ganges and Brahmaputra valleys.

Luvisols are relatively fertile, but tend to be shallow or gravelly (especially Orthic Luvisols). When irrigated, they can grow rice (as in Central Burma), cotton and tobacco, and winter wheat and soybeans (in China), but waterlogging is always a problem. Where water is lacking, such soils are best used for pasture. Natural vegetation is of little value and reforestation is difficult. Luvisols are commom in India and Sri Lanka in areas with long dry seasons. In Java and Thailand, efforts have been made to establish teak plantations on these soils. Extensive fruit orchards occur in the Shantung areaof China (Chromic Luvisols).

Nitosols are good, deep soils generally found on level or gently undulating land. Although they lack high intrinsic fertility, they are among the most productive soils in the region, due to their physical properties, depth, and resistance to erosion. They occur extensively on the lower volcanic ranges of Indonesia and the Philippines, locally in Kampuchea and on the plateaux of Burma, Thailand and the east coast of India.

The other soils of this grouping occupy limited areas in the region, though they may be locally important.

2. Soils with strong fertility limitations
(Acrisols, Ferrulsols and Podzols)

These soils cover the major part of Southeast Asia and China. Most are chemically poor, being acidic and low in organic matter, phosphorous, cation exchange capacity and base saturation (as in Humic Acrisols and Orthic Acrisols). The natural vegetation consists of productive forests. Nevertheless they have good physical properties; with regular fertilizer applications, adequate erosion protection and careful water control, annual and perennial food and commercial crops can be grown successfully. Pineapples and other tropical fruits do well (but need heavy applications of fertilizer). On the other hand, Ferric Acrisols and Gleyic Acrisols are much less acidic and more fertile. They occur widely in Southeast China, where rice and tea, as well as maize, sugarcane and potatoes are grown. They also occur in Northeast India, and are used for growing rice and potatoes under shifting cultivation. In Sri Lanka, they are mostly under forest, but also support cocoa, tea, coconut and rubber plantations and fruit orchards.

3. Shallow soils, mostly on steep slopes
(Lithosols, Rankers and Rendzinas)

These soils are stony, shallow and subject to erosion. They occur in steep mountain areas, mainly in Central Asia (where they are most common), in the Himalayas and in Southeast Asia, and are best left under forests and permanent vegetation to encourage absorption of rainfall and check runoff. Terraces can be constructed in some humid areas which allow arable crops to be grown satisfactorily, or even tree crops (where the underlying rock is sufficiently broken to allow deep root penetration). In South Asia, poor crops of upland rice, millet, sorghum, wheat, barley and mustard are grown. Where gently sloping, moderately deep soils with sufficient moisture are available, fruit crops like mango, papaya, avocado, or cashewnut, can be grown. In Central Asia, they are used mainly for summer mountain pastures, and in the Pacific Islands, they have a potential for tree crops on uplifted coral terraces.

4. Poorly-drained soils
(Gleysols, Planosols and Histosols)

These soils are deficient in nutrients, and not only are they affected by deep flooding, but drainage causes shrinkage of organic matter and possible irreversible hardening of the soil. The main exceptions are Eutric Gleysols which are fertile lowland soils and are widely cultivated with rice (as in China's Yangtze region).

Large and contiguous areas of Gleysols and Planosols occur in Burma, Bangladesh and the Central Asian steppe zone. In India and Nepal they are found in the foothills of the Himalayas, mainly under swamp forest. Where rainfall is adequate or irrigation can be provided, these soils are best adapted to rice cultivation. In Bangladesh they are used mainly for cultivation of rice, jute or mesta (kenaf). Small areas in Sri Lanka are used for growing rice and vegetables, but under careful management involving drainage. Fertilizers and irrigation can greatly increase their potential, and two annual crops are then possible. However, they are seldom cultivated during the dry season.

Histosols are rich in organic matter and cover large areas of Southeast Asia, especially Indonesia (where the natural forests they support are exploited for timber), the Ganges flood plain (where most support tall reeds and grasses that are often cut to provide material for thatching or mats), and the Central Asian lowlands. Eutric Histosols are common in estuaries and along flat coastal areas of the Papua New Guinean mainland, where they may have large mangrove resources.

Crop yields are generally low because of poor drainage, but increasing population pressure is encouraging reclamation of these soils for production. In Northeast Sumatra and South Kalimantan, rice is planted on land progressively exposed by receding floods.

5. Heavy-cracking clay soils
(Vertisols)

These soils are heavy and difficult to work. They expand on becoming wet and shrink on drying, so that cracks form. They are extremely hard during the dry season and of plastic consistency after rainfall, making it difficult to use farm implements. Irrigation is generally necessary to obtain sustained crop yields. Because of the poor internal drainage of these soils, ridging and shallow-surface drains help to improve crop production. While unsuitable for tree crops, they can sustain continuous cropping and do not require a rest period for recovery. However, where irrigation is unavailable, overall productivity is low and

dry-season utilization is limited to low-intensity grazing. In general, permanent crops, such as paddy, sugarcane or adapted perennial crops, are more desirable than repeated cycles of annual crops that require frequent tillage of the land.

74% of Vertisols are found in India where they are mostly under rainfed cultivation, the main crops being cotton, millet, sorghum, wheat, pulses, tobacco, groundnuts and sugarcane. Another 17% are found in the lowland areas of Eastern China, and about 9% in Burma, Kampuchea, Indonesia, Philippines and Thailand. Where sufficient irrigation is available, one or two paddy crops can be grown annually.

6. Coarse-textured soils
(Arenosols and sandy Regosols)

These are sandy soils with low moisture and nutrient-holding capacity. They occur as stony and gravelly deposits and sand dunes in the arid regions of India and Pakistan, or as gravelly young coral reefs in the Pacific Islands, and are used mainly for sparse grazing of nomadic herds of cattle, sheep and goats. In the high rainfall areas bordering the coasts of India and Sri Lanka, the level or gently undulating parts of sandy areas having fresh ground water support coconuts. These soils also occur to a limited extent in Southeast Asia, mainly in Kalimantan.

Many of these soils suffer considerable erosion. In a sub-humid or humid climate, they are suitable for afforestation. Only with heavy use of fertilizers or organic manures and sprinkler irrigation can they be developed for high-yielding crop production. Elsewhere, improved pastures can be obtained in semi-arid to sub-humid areas by controlled grazing.

7. Semi-desert and desert soils
(Xerosols and Yermosols)

These soils are fertile but require irrigation and applications of nitrogen and phosphorus for sustained crop yields. The problem of low organic matter content can usually be overcome by combining intensive cropping with good management practices, including adequate use of fertilizers. Without irrigation, they are suitable only for traditional grazing. However, under rainfed conditions, minor improvements can be made with Xerosols by including grams, lentils and other legumes in crop rotation, and by using phosphate fertilizers. Using lucerne with phosphate fertilizer in rotation with wheat considerably increases wheat yield and provides forage for livestock.

More than a third of Mongolia is covered by these soils. They also occur in the arid areas of India and Pakistan, where low and sporadic rainfall makes crop production risky. In Pakistan, tubewells are used to lower the water tables in areas where groundwater is not very saline and can be mixed with canal water. In areas with saline groundwater, a complete system of drains and continuous cropping are needed so that the movement of water and salts is downward into the drains.

8. Salt-affected soils
(Solonchaks and Solonetz)

These soils are fundamentally poor and in many cases not worth improving. Their reclamation for agriculture is expensive, even where sufficient irrigation water is available. For development under irrigation, drainage is required to lower the water table, and large quantities of water are needed to leach the salts from the root zone. To control alkalinity after the leaching of the salts, gypsum is added or strong-rooting, alkali-tolerant grasses are cultivated for a few years.

They are found mainly in China, Mongolia, India and Pakistan. Costly attempts at reclamation have been made with the result that in some areas these soils are found under rice, wheat, sorghum and berseem clover. However, they usually remain bare, sometimes with a sparse cover of grass or shrubs which provides scant grazing. In the humid areas of Bangladesh, Sri Lanka and Southern India, they are associated with tidal flooding in coastal areas.

9. Miscellaneous land units

These include salt flats, rock debris, snow caps, and shifting sand and dunes, and are found mainly in China, Pakistan, India, Bhutan, Mongolia and Nepal.

Steep slopes pose serious limitations to cultivation throughout the region. Table 1.2 shows that 55% of Central Asia falls within the steepest class (over 30%). In South and Southeast Asia, 60% of the land has slopes higher than 8%. In the Oceanic region, the comparable value is 73%. Even though soils with no serious fertility limitations cover 15-30% of the land area, many have slope limitations and are subject to erosion. However, they are suitable as extensive wildlife and plant genetic reserves.

Table 1.2. Slope classes in Asia and the Pacific

Region (a)	Slope class A (0-8%)	B (8-30%)	C (over 30%)	Total
South and Southeast Asia				
Area (million ha)	361.2	273.8	262.6	897.6
Percentage	40	31	29	100
Central Asia				
Area (million ha)	287.9	202.9	596.6	1 087.4
Percentage	26	19	55	100
Oceanic Asia				
Area (million ha)	13.9	1.8	35.6	51.4
Percentage	27	4	69	100

(a) South and Southeast Asia = Bangladesh, Bhutan, Brunei, Burma, East Timor, Hong Kong, India, Indonesia, Kamuchea, Lao, Macau, Malaysia, Maldives, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam.

Central Asia = China, Korea (DPR), Korea (Rep), Mongolia.

Oceanic Asia = Fiji, French Polynesia, Guam, Kiribati, New Caledonia, Pacific Islands, Papua New Guinea, Samoa, Tonga, Vanuatu.

Source: Ref. (1).

1.2 LAND DEGRADATION

Land degradation is the partial or total loss of productivity as a result of soil erosion, salinization and alkaliniztion, waterlogging, depletion of plant nutrients and organic matter, deterioration of soil structure, or pollution.

It is a serious problem in the region. For example, of the total area of 328 million hectares in India, 90 million are affected by water erosion, 50 million by wind erosion, 7 million by salinity, and 20 million by flooding, a total of 167 million or 51% of the total area. (2)

The degree of soil erosion is illustrated by estimates of the suspended sediment loads of major rivers. One estimate, based on 16 major rivers of the world, is that, for a drainage basin of approximately 21 million sq km, the suspended load is an average of 363 tonnes per sq km of the drainage basin. Averages for the Yellow, Ganges and Brahmaputra rivers are 2 800, 1 500 and 1 100 tonnes per sq km respectively. (3)

Table 1.3 Sediment yield in selected rivers in Asia

River	Drainage basin (thousand sq km)	Average annual suspended sediment load (million tonnes)	Erosion (tonnes/sq km)
Yellow	673	1 887	2 804
Ganges	956	1 451	1 518
Brahmaputra	666	726	1 090
Yangtze	1 942	499	257
Indus	969	435	449
Irrawaddy	430	299	695
Mekong	795	170	214
Hsi	330	86	266

Source: Ref. (3).

In a recent study on the potential population-supporting capacities of lands in the developing world (4), the effects of water and soil erosion were taken into consideration in assessing land potential. Prior to this study, regional assessments of soil loss had not been possible because of the lack of suitable climatic, soil, slope, texture and landuse quantifications on which to base the assessments. Efficient methods still need to be found for translating calculated rates of soil loss into decreases in potential productivity. FAO is working on this problem with the International Institute for Applied Systems Analysis (IIASA).

However, in the interim, by using estimates of soil loss in different groupings, the effects of unchecked soil erosion on long-term productivity (1975 to 2000) have been quantified. The results are striking, particularly for Southeast Asia (Table 1.4). The area of potential rainfed cropland could be reduced by 35.6%. Even more striking is a reduction by 38.6% in the sustainable potential of rainfed crop productivity. The overall loss in productivity due to unchecked soil erosion in the region is estimated at 12.4%. This is in fact better than in other regions of the developing world because of the large areas under irrigation.

Table 1.4 Effects of unchecked soil erosion on land productivity in Southeast Asia

	%
Decrease in area of rainfed cropland	35.6
Decrease in rainfed crop productivity	38.6
Decrease in total land productivity	12.4

Source: Ref. (4).

Irrigated lands also face the threat of degradation through salinization and waterlogging. The total extent of salt-affected soils in the Indus plains is approximately 6 million ha, of which 3.25 million lie in canal command areas, constituting about 23.3% of these areas. Waterlogging is a problem in another 300 000 ha of non-saline cultivated lands. (5)

Chemical degradation of soils may occur if nutrients in the soils are not replenished. During the last two decades, the increasing use of mineral fertilizers has led to impressive yields in the region, but farmers cannot always afford to purchase these fertilizers.

Despite the increased use of fertilizers, subtantially more macronutrients are being removed annually from the soil than are being applied to it as mineral fertilizers. Some of the nutrients removed are replaced by those in farmyard manure, straw, etc., but organic manure is limited in many countries of the region. On average, the nutrient level is decreasing.

1.3 LAND MANAGEMENT

Land resources are of paramount importance for the survival and welfare of people and the economic independence of countries. So, as the World Soil Charter states, it is "a major responsibility of governments that land-use programmes include measures toward the best possible use of land, ensuring long-term maintenance and improvement of its productivity, and avoiding losses of productive soil." (6) The ability of land to produce food, fibre and other agricultural products is determined not only by the nature and extent of soils, but also by climate, the availability of water, the genetic potential of plants and animals, and land-use and management techniques. The fact that only about a fourth of the region's soils are suitable for agriculture without serious limitations, is indicative of the degree of soil management needed to produce suitable yields on a sustained basis.

1.3.1 Land use and watershed management

The productivity of agricultural lands depends not only on how they are managed, but also on how non-agricultural lands in the same river basin are used. For instance, it makes little sense to incur heavy costs by providing irrigation facilities, while denuding watersheds in the upper reaches of a river basin and ignoring the threat of recurring floods. Destruction of vegetation and shortage of wood are forcing many peasant households in the region to use animal manure and crop wastes as fuel, instead of returning them to the cultivated soil. Most developing countries in the region do not yet have integrated land and water management systems, because of lack of awareness or appropriate institutions.

Comparative land-use patterns in the region are shown in Table 1.5 and Annex Table 3. In 1983, arable and permanently-cropped lands constituted 19% of the total land area in the region, while forests, woodlands and pastures covered 48.3%. Compared with the world average, Asia and the Pacific Region have slightly more arable and cultivated lands. The trend in land use in the 1974-83 period was generally a slight decline in arable and cultivated land (-0.8%), although at the sub-regional level, Central Asia's cultivated lands increased by 18.5%. The regional increase of 32% in food production during the same period must be attributed to, on the one hand, more intensive agriculture and higher per unit productivity (especially in South and Southeast Asia), and on the other, an increase in arable land area in China. The conversion of arable land for urban and rural development is a striking feature of the Oceanic and South/Southeast sub-regions.

Table 1.5. Land use in Asia and the Pacific

Region	Land use				
	Arable	Permanent crops	Permanent pasture	Forest & woodland	Other(a)
	(million ha)				
South and Southeast Asia	259.1	15.2	35.5	326.7	208.0
Central Asia	103.0	3.6	409.5	161.5	433.3
Oceanic Asia	0.4	0.8	0.5	37.2	15.4
Total	362.5	19.6	445.5	525.4	656.7
World total	1 371.6	100.1	3 157.4	4 068.4	4 383.5

(a) Wastland, built-on land, and unused but potentially productive land.

Source. Ref. (7).

Permanent pastures have steadily declined since 1974 in all sub-regions of Asia. Forests and woodlands have slightly declined in Oceanic and South and Southeast Asia, but have increased in Central Asia by 10.7%.

1.3.2 Organic resources

Under technically advanced systems of farming, soil fertility is maintained by means other than taking the land out of cultivation. Mineral fertilizers are used (see Chapter 10) and, to a smaller extent, organic manures.

Conserving and recycling urban and rural wastes for manure making deserves greater attention. Most countries in the region have a shortage of fertilizers, yet they do not fully recycle organic wastes. The potential for recycling these wastes is prodigious. In China, organic wastes (including human excreta) is collected daily from villages and cities for use in agriculture. From 1952 to 1966, between 28% and 38% of the nutrients applied in agriculture came from nightsoil. In 1966, 299 million tonnes wet weight of nightsoil, about 90% of the excreta in China, were collected and recycled. Elsewhere in the region, the recycling of human wastes is sporadic and usually on a small scale. About 80 million

tonnes dry weight of human excreta is produced in the region oer year, containing 9.7 million tonnes of nitrogen, 1.4 million tonnes of phosphorus and 1.9 million tonnes of potassium. Recycling this waste could reduce pollution and disease, and help increase food oroduction. (8)

Cattle dung and crop residues are used in India and Pakistan as fuel. India burns an estimated annual 73 million tonnes of cowdung and 41 million tonnes of crop residues. Farmers must be provided with an alternative fuel, in order to dissuade them from using cowdung for energy. India, China and Korea have popularized family-owned biogas plants, the effluent being used to fertilize crop lands.

1.3.3 Biological nitrogen fixation

The increasing pressure on land resources (specially arable and good quality farmland) in the region has resulted in the virtual elimination of fallow periods. Continual cultivation results in a reduction in the land's fertility and ultimate degradation, unless nutrients are returned through fertilizers, green manuring, etc. Since fertilizers are sometimes beyond the reach of farmers (economically and logistically), other locally available technologies must be used to prevent degradation and allow an increase in the per unit productivity of the land.

The symbiotic genus Rhizobium, commonly associated with legumes can contribute to the nitrogen fertility of soil. Most members of the family Leguminosae are widely distributed in the tropics and sub-tropics. Green manuring with leguminous crops (i.e. ploughing under a crop for the purpose of improving the soil) was once a common practice in the region. This was good when one croo-growing season was used to regenerate and improve fertility, and the other to raise a crop for economic gain. (9)

While green manuring may not be possible today, one fodder or grain legume can certainly be grown in multiple cropping sequence, involving two or three crops. Legumes can also be fitted into inter-crop systems with sugarcane, sorghum, cotton and maize. Even in fully established orchards, several fodder legumes can be introduced. Plantation crops also offer opportunities for multi-layer cropping with legumes. The diversity and adaptability of cultivated legumes in developing countries are remarkable. The total nitrogen contained in single crops of legumes ranges from a few kg/ha to as much as 300 to 400 kg/ha.

Several nitrogen-fixing organisms are used in the region. In China, India and Vietnam, Azolla and blue-green algae (Anabaena azollae) are in common use. Azolla is a floating, branched fern with small leaves and simple roots which hang into the water. Under optimum conditions, Azolla yields large quantities of green matter (about 160 t/ha) over a period of 3 to 4 months, containing about 425 kg of nitrogen (more than 2 tonnes in terms of ammonium sulphate, or about 1 tonne of urea).

Blue-green algae, belonging to a group of heterogeneous cryptogamic plants containing chlorophyll, are highly efficient users of solar energy and have the ability to fix nitrogen. In China, both basic and applied research on blue-green algae is being carried out. A field prepared for rice cultivation is flooded and algae (750 kg/ha) are spread as inoculum thus increasing yields by about 10%. The production of bio-fertilizers based on blue-green algae is also of commercial interest in India and China.

(1) FAO/Unesco. Soil Map of the World, Vol. VII: South Asia;
1978 Vol. VIII: North and Central Asia; IX: Southeast Asia; Vol. X: Australasia. Paris: Unesco.

(2) FAO. Soil and Water Conservation, Committee on Agriculture,
1980 6th Session, COAG/81/8. Rome.

(3) UNEP. The Resources of Development: UNEP Asia-Pacific Report
1982 1981. Bangkok: UNEP Regional Office for Asia and the Pacific.

(4) FAO/UNFPA/IIASA. Potential Population-supporting Capacities
1982 of Lands in the Developing World, Technical Report of Project FPA/INT/513. Rome: FAO.

(5) Bashin Choudhri, M., Alim Mian, M. & Rafiq, M. Nature and Magnitude of Salinity and Drainage Problems in relation to Agricultural Development in Pakistan, Pakistan Soils Bulletin No. 8. Lahore: Soil Survey of Pakistan.

(6) FAO. World Soil Charter. Rome.
1982

(7) FAO. FAO Production Yearbook 1984. Rome.
1985

(8) Edwards, P. Recycling Organic Wastes: Energy Conservation,
1982 Pollution Abatement and Fish Production, in Asia and the Pacific: Experience and Prospects. Nairobi: UNEP.

(9) Singh, A. Use of Organic Materials and Green Manures as
1975 Fertilizers in Developing Countries, in Organic Materials as Fertilizers, FAO Soils Bulletin No.27. Rome: FAO.

2. WATER RESOURCES

The availability of fresh water has traditionally determined human settlement and cultural patterns. Many of Asia's advanced civilizations were rice-growing, established in the flood plains of major river basins such as the Ganges-Bramahputra, Irrawaddy, Indus, Mekong, and Yellow. (1) (Annex Table 4 gives basic data for some rivers in Asia.)

These rivers, large natural lakes (such as Songkhla in Thailand and Laguna de Bay in the Philippines), and countless smaller perennial and intermittent lakes, are the major sources of freshwater supply. In arid zones and on small islands in the region, groundwater is the most reliable source of fresh water. In humid mainland Asia and the larger islands of the Pacific, where most of the population lives, surface streams are supplemented to varying degrees by groundwater.

The region has dry deserts, wet tropical rain forests, and various terrestrial-climatic zones in between. Pakistan has summer monsoons varying from 100 mm of rainfall in the south, to 750 mm in the north. The Indian arid zone experiences both desert and monsoon conditions and suffers periodically from drought as well as flooding. Asia has the world's biggest share (30%) of annual precipitation runoff, although the heaviest concentration in terms of average depth of runoff by region is found in South America at 685 mm, while in Asia it is 324 mm.

In the more humid tropical countries of Asia and the Pacific, there is an annual surplus of rainfall and runoff. However, the timing is such that without storage facilities, water demands are not met when required. Changes in watershed characteristics may be partly responsible for the erratic climate causing periodic floods and droughts. Bangladesh and, to a lesser extent, Northeast Thailand, suffer from either too much water or not enough. Even where rainfall is more consistent in monsoon countries, about 80% falls during a concentrated five-month period. Table 2.1 shows the average annual rainfall in some Asian countries.

The seasonal nature of runoff in most countries complicates the development of surface water resources. High flood peak discharges create problems in the design, construction and management of storage facilities and emphasize the need for effective flood forecasting and warning systems.

A high concentration of rainfall results from the southwest monsoon (June to September). However, this basic pattern is altered by local topography and climatic characteristics; as a consequence, hydrological regimes vary from one river to another. The smaller the catchment area, the larger the deviations from this basic pattern. For instance, all large rivers in the region's northern hemisphere have only one period of high flood, which can include several peaks caused by monsoon precipitation. This is followed by a recession which is altered by precipitation of the classical type. In addition, snow-fed rivers have a sustained base flow in their upper reaches, but the contribution of snow becomes insignificant in the lower reaches. (2)

Water is an important basic resource, but it assumes still greater importance in countries where food suppy is insufficient for an ever-increasing population, and where there is a pressing need for power to develop modern industries. Until comparatively recently, river development projects were designed for a specific purpose, e.g. irrigation, hydro-electricity, or water supply, according to the needs of the locality. This often resulted in the haphazard development of a river basin. It has become increasingly apparent that only by planned, integrated, long-range development, can a river basin be put to maximum use and the water resources fully exploited for the benefit of virtually every form of economic activity.

Table 2.1 Average annual rainfall and runoff in some Asian countries

	Average annual rainfall	Average annual runoff		Annual runoff coefficient
		Volume (million m^3)	Equivalent depth (mm)	
1. Above 2 000 mm				
Hong Kong	2 360(a)	1 320	1 270	0.59
Indonesia	2 620(a)	2 530 000	1 250	0.48
Lao	2 000	273 000	1 150	0.57
Malaysia	2 850	456 000(a)	1 370(a)	0.48(a)
New Zealand	2 010	397 000	1 496	0.74
Philippines	2 360	322 989(a)	1 076(a)	0.45
Sri Lanka	2 010	43 200	659	0.33
2. 1 000 to 2 000 mm				
Bangladesh	1 930	123 000(b)	860	0.45
Burma	-	1 082 000	1 600	-
Kampuchea	1 850	88 100	590	0.32
India	1 170(a)	1 780 000(a)	543(a)	0.47(a)
Nepal	1 880	170 000	1 210	0.64
Korea (Rep. of)	1 159	63 000	641	0.55
Thailand	1 420	110 600(a)	214	0.15
3. Below 1 000 mm				
China	600	2 680 000	281	0.43
Mongolia	220	24 556	16	0.07
Pakistan	280	183 400	228	-

Except where otherwise indicated, all information was obtained from Water Resources Journal, September 1973. (ST/ECAFE/SER.C/98)

(a) Data from country reports presented to the United Nations Water Conference, Mara del Plata, 1977.

(b) Data from country paper presented to the International Conference on Water for Peace, Washington, 1967. An additional runoff of 1 234 000 million m3 are received from outside Bangladesh.

Source: Ref. (2).

2.1 GROUNDWATER

Since 1960, groundwater has been regarded as a way of obtaining quick results from irrigation and as a safe source of drinking water. Many projects are being undertaken using high discharge tubewells which, in some areas, are lowering water tables to the point where shallow wells are failing. But the costs involved in replacing large numbers of wells need to be considered. Studies to determine how best to combine irrigation use and village water supply are limited, as are data on groundwater resources for most countries in the region. India, where considerble progress has been made in groundwater exploration, is one exception. Many countries of the region may have substantial groundwater resources, but quantitative and qualitative assessments of these resources on a national rather than on a local level have still to be made. (4)

In many parts of Asia and the Pacific, the amount of groundwater used is much less than the natural rate of replenishment of the aquifer systems. But, from a long-term point of view, where natural replenishment is limited or zero, as in the case of deserts, groundwater development becomes a process akin to petroleum exploitation, which will eventually become exhausted. During the process of exploitation, groundwater may become polluted by drainage from irrigated lands, or salt water can encroach, especially in coastal areas. (2)

During the last decade, a large number of Indian farmers changed to irrigation devices using groundwater supported by the country's rural electrification programme. About 5 million pump sets or tubewells have been energized in India which has immense groundwater resources - 26.5 million ha/m - which can be profitably tapped and utilized. The land area that can be irrigated, using both ground and surface water, has been assessed at 113 million ha. Up to 1979-80, groundwater resources had already contributed an irrigation potential of 22 million ha. (5) But in several areas of the country, the water table is receding by up to a metre a year. Use of surface water has caused a rise in groundwater levels in some areas, resulting in soil salinity. In such areas, the carefully monitored, combined use of surface and groundwater will help to ensure continued crop production.

2.2 IRRIGATED FARMING

About 50% of the developing world's irrigated land is in the Asia and the Pacific, and this area could be at least doubled by proper husbanding of water resources. (6) Irrigation accounts for about 70% of the total water use in the region, although the proportion varies between 80 and 90% in some countries. (2)

The benefits of irrigation for crop production are illustrated in Table 2.2, which relates country rice yields to the degree of applied water control and management. Higher crop yields are only one of the potential benefits of irrigation. Improved control and management of water permit more intensive land use; yearly fluctuations in crop production due to weather variations are minimized; reduction of water wastage means that the water can be used productively elsewhere; and all these factors combine to increase the harvested area.

Improving supply and distribution is not sufficient in itself to guarantee the continued effectiveness of irrigation. Of equal importance is the provision of proper drainage to remove surplus water and to control water and salt balances in the soil. In 1975, the equipped irrigated area in the region was 60.5 million ha. Improvements to existing irrigated areas were targeted by the 1977 United Nations Water Conference to be

spread to some 30 million ha by 1990; the additional area to be irrigated by 1990 being 13.8 million ha. It was estimated that the land in need of drainage was about 62.5 million ha in 1975; improvements should be brought about on 43.4 million ha by 1990. The total cost of irrigation and drainage improvements in the region between 1975 and 1990 (apart from new works), was estimated at approximately US $22 billion.

Table 2.2 Paddy-rice yields related to water control and additional inputs

Country	Maximum rice yield (tonnes/ha) 1974-76	1984	Degree of water control	Additional inputs
Lao	1.3	2.1	None (rainfed, uncontrolled flooding)	Nil
Kamuchea	1.3	0.9	Measures to eliminate floods	Nil
Burma	1.8	3.1)	Measures to eliminate drought	Low fertilizer application
India	1.7	2.1)		
Thailand	1.8	2.0)		
Korea, Rep.	5.5	6.5)	Irrigation and drainage measures	Low to medium fertilizer application
Malaysia, West	2.7	2.7)		
Pakistan	2.3	2.5)		
Sri Lanka	2.0	3.0)		
Viet Nam	2.2	2.7)		
China	3.5	5.3)		

Source: Ref. (7).

In making these investments, consideration should be given to the development of national water grids. An example is the proposed Indian National Water Grid, planned to cover the entire Indian peninsula at an estimated cost of over US $4 billion. The project will link all the major rivers of India - Ganges, Brahmaputra, Narmada, Tapti, Godavari, Krishna, Penmar and Kaveri. The agricultural sector primarily will benefit by the creation of this grid, since 80% of the population depend on agriculture. The grid will provide reserves of water in areas prone to drought; townships will grow on both banks of the grid; and it is hoped that water will become a unifying factor and eliminate interstate disputes.

Irrigation is a means to an end - the production of food and fibre. For the optimum use of resources, irrigation planning and development need to be carried out in the context of national plans which consider non-irrigated as well as irrigated land, within overall rural development plans. Thus, there should be close cooperation between the authorities responsible for irrigation and those responsible for agricultural and

pastoral activities. In some cases, these responsibilities are merged in one department, but where that is not the case, there is need for institutional arrangements to ensure plannned rather than ad hoc collaboration. Short-term plans should be incorporated into long-term perspective planning. (4)

Traditionally, irrigation takes place on the most productive agricultural lands. Carelessness or ignorance of irrigation management techniques has led in many cases to such a decline in productivity that settlements have had to be abandoned or, in more recent years, expensive rehabilitation measures have had to be taken. While water is essential, it is only one of the inputs to irrigated agriculture and, quite apart from irrigation efficiency, the productivity associated with water use can vary greatly, depending on the adequacy of other inputs, particularly the land itself, fertilizers, pesticides, and seed and plant varieties. In the last resort, the efficiency of the whole system depends on the skill of the individual irrigator.

In some countries, the authorities responsible for irrigation supply have little or no responsibility for farm design and operation, and the economic development associated with irrigation projects has often lagged behind that envisaged. Water-user associations and rural cooperatives are of value in improving communication between water authorities and water users, resulting in a considerable increase in the overall efficiency of water systems and of productivity generally.

Despite large investments in irrigation systems, the level of efficiency and productivity achieved by farmers has often proved disappointing, and management and maintenance of delivery and drainage systems unsatisfactory. Consideration should be given to the improvement of existing irrigation systems with the objectives of raising productivity with minimum cost and delay, improving the efficiency of water use and preventing waste and degradation of water resources.

China provides a good illustration of how efficient use and maintenance of irrigation systems can be achieved at farm level. About 60% of China is mountainous and hilly, and 20% grassland. The cultivated area is only 20% (2 million sq km) of the total area. Annual precipitation ranges from 100 - 200 mm in the northwest to about 1 600 mm in the southeast. (8)

Since 1949, China has been engaged in a vigorous water conservation programme, including the construction of 300 large, 1 900 medium-sized, and 70 000 small reservoirs, and 6 million small ponds. The capacity of pumped irrigation and drainage stations has increased from 90 000 hp to 55 million hp, and 2 million tubewells have been installed. The irrigated area has increased from 16 million to 46.6 million ha. Water utilization plans are drawn up annually or before each irrigation season so that the water can be allocated in time for irrigation. Effective extension techniques are adopted and users are encouraged to avoid "running-water" irrigation, and to apply water individually to each plot; to use shallow water irrigation; to water day and night; and to control the groundwater level in the soil.

Projects are identified with those who expect not only to benefit from them, but who also help in their construction. As part of the spirit of local self-reliance, the State is seen as a supplementary resource, to be called upon only if necessary. The planning, design and

supervision work is carried out by a production team. At each level, plans are approved by the next highest authority. Each area establishes a team to carry out a planned system of maintenance. One of the reasons for converting open irrigation and drainage systems into covered sytems is the reduction in maintenance requirements.

In order to optimize water resources, the Chinese advocate the "five firsts" slogan:

- First use natural flow of streams and return flow from irrigation areas, then water from ponds and small reservoirs.

- First use water from small ponds and reservoirs, then water from main reservoirs.

- First irrigate fields in high lands, then in low areas.

- First irrigate large plots and fields, then scattered fields.

- First irrigate crops with the greatest need, then the others.

2.3 RAINFED AGRICULTURE

Rainfed agriculture, which characterizes more than 75% of the cropped lands of Asia and the Pacific and supports about 75% of the rural population, is complex and diverse. (9) The monsoon is uncertain and drought and floods have become annual features. Rainfed farming is high-risk farming, particularly in the monsoon climate where heavy rains occur for periods varying from 3 to 8 months, followed by extended dry periods of 4 to 9 months. In many areas, there is a high degree of yearly variability, not only of total rainfall but also of commencement and termination of the rainy season. Frequently, there are long, dry periods within the rainy season. A prolonged dry period at the critical stage of crop growth may result in the complete loss of a crop. The uneven distribution of rain in space and time makes crop planning difficult. (10)

Yearly fluctuations in agricultural production are large. In rainfed areas, the most important factor limiting production is the lack of control over water. Because of the variability of rain in space and time, both deficiency and excess of rain contribute to instability in agricultural production. Droughts or floods occur frequently in one or more parts of the region. New technologies in crop production, based on high-yielding and fertilizer-responsive varieties, have only benefited farmers with access to irrigation. This not only creates regional disparities but also widens the gap between rich and poor farmers. The increase in agricultural production from irrigated areas alone, however significant, will not lead to stability in production or meet the needs of growing populations unless production in rainfed areas increases considerably.

In South and Southeast Asia, the problem of variability of rain is persistent and acute. In the monsoon climate, 80% of the rain falls in a period of 4 to 6 months. This leads to the adjustment of cropping to make the best use of the rainy period. But when the monsoon is delayed, or there are long dry periods, or the rains withdraw early, the cropping patterns for the entire year are disturbed. Hence, production of rainfed crops in a monsoon climate is more diffficult and complex than in the rainfed areas of temperate climates. In the humid and sub-humid tropics, excessive runoff during periods of intense rain not only causes serious erosion in the catchment areas but also leads to floods in the valleys and plains.

The effects of rainfall are influenced by the soil's physical and chemical properties, particularly its moisture retention and transmission characteristics. Choice of crop in a particular area will thus depend on both rainfall and soil characteristics. Fine-textured soils with low permeability and impeded drainage are preferred for rice production, but are entirely unsuitable for legumes such as mung bean (Vigna radiata) and groundnut (Arachis hypogaea L.). The problem is further complicated by the wide variation in soil quality. By matching the soil/climate unit (agro-ecological zone) with the requirements of crops, the potential and limitations of various cropping systems can be assessed. The diversity of the agro-ecological settings of rainfed agriculture calls for location-specific technology to improve production.

In about two thirds of tropical Asia, rainfall is normally adequate for the rainfed production of annual crops and, in at least one fifth of the region, for perennial croos. Table 2.3 shows that in 15 countries of Asia, only about 27% of the potential arable area has good rainfall. Some 25% has low rainfall, and another 26% is classified as "problem areas".

Table 2.3 Land resource potential in Asia in 1975

Land and water classes (a)	Potential arable land	
	(million ha)	(% of total)
Good rainfall (b)	90	27
Low rainfall (c)	83	25
Problem areas (d)	86	26
Naturally-flooded areas (e)	63	19
Desert (f)	14	4
Total	336	101
Suitable for irrigation (g):		
Fully irrigable	121	36
Partially irrigable	97	29

(a) Suitability classes from FAO's agro-ecological zones study are used (11). The four classes (very suitable, suitable, marginally suitable and not suitable) relate to the anticipated yield as a percentage of the maximum obtainable under optimum agro-climatic and soil conditions; thus, yields on marginally-suitable lands may be as low as 10% of the optimum.

(b) Land with rainfall providing for 120 to 270 growing days, soil quality very suitable or suitable.

(c) Rainfall providing for 75 to 120 growing days, soil quality very suitable, suitable or marginally suitable.

(d) Rainfall providing for more than 270 growing days, soil of all usable qualities, plus the zone of 120 to 270 days with soil marginally suitable.

(e) Land under water for part of the year and lowland rainfed paddy fields.

(f) Desert land under irrigation.

(g) Area under irrigation (partially or fully equipped), plus area suitable for irrigation in the future.

Source: Ref. (10)

The nature and magnitude of crop production is determined by the soil and water regimes in a given climatic system. Agronomic practices should complement and supplement ecological systems to maximize and sustain agricultural production.

To obtain an approximation of the production potential of the world's land resources, FAO undertook a global study of potential land use on the basis of agro-ecological zones. (12) In Southeast and South Asia, only 14% and 18% respectively of the soils have no serious limitations for agriculture; nearly 85% suffer from drought, mineral stress, shallow soil depth or excess water. In high-rainfall areas, heavily leached soils constitute 70% to 90% of the total land area. These soils are acidic, low in nutrients and susceptible to erosion. Farmers cultivating these lands have evolved practices based on the experience of many generations. Some of these practices could be applied to similar agro-ecological zones elsewhere.

Rice is the most important food crop in the region. Many different types of rice cropping patterns exist, ranging from rainfed lowland regimes to rainfed deep-water, rainfed upland and tidal wetland regimes, all of which have their own special, local characteristics depending on the soil types and temperature regimes. In some areas, two crops, followed by an upland crop can be grown, while in others, such as India's Bihar Plateau, Eastern Madhya Pradesh, Orissa, parts of West Bengal and Andhra Pradesh, the vaguaries of rainfall patterns make even one crop risky. When the monsoon withdraws early (e.g. during September), leaving the crop in the flowering and grain-filling stages, loss is complete, resulting in famine. Some areas, particularly the excessively drained uplands, are unsuitable for rice production. These areas can be better used for growing upland crops such as finger millet or groundnut. In some areas in Madhya Pradesh, where the rainy season is short and the soils are of fine texture, soyabean and sorghum could replace rice.

Rainstorms of high intensity occur most years with considerable runoff from the uplands; in the bunded fields of the lowlands, water depth may be 30 to 45 cm, which in the early stages of plant growth affects tillering. Storing the runoff and drainage water in gullies or stream beds from catchment areas of 10 to 20 ha by constructing small dams and recycling in periods of drought in rainy seasons, will stabilize rice production.

In Northeast Thailand, failure of rice crops due to drought is common every two to three years. This area has 1 000 to 1 400 mm of rainfall, with peaks in May and September. The soils are sandy with low moisture storage capacity. The farmers wait for enough rain for puddling and transplanting. In the years when the rain is delayed, old seedlings have to be used and sometimes new ones have to be raised. This leaves little time before the rainy season ends. Direct seeding of rice with the first showers in April/May ensures a satisfactory crop. For direct seeding, preparation of land after harvesting the rice crop is necessary. The development of suitable implements for land preparation and direct seeding of rice should be given priority; urgent attention should be given to identifying cultural practices rather than chemical control; the runoff should be stored in small reservoirs to provide irrigation during periods of drought. Development of groundwater irrigation should be a priority and studies undertaken to identify exploitable aquifers and areas of recharge of groundwater.

In areas having more than 6 wet months (200 mm of rainfall per month), two crops of rice can be taken in the lowlands, midlands and fine-textured soils. These areas include Mindanao and Visayas in the Philippines, Sumatra, West Java, Kalimantan and Sulawesi in Indonesia, and most of Malaysia.

Maize is another important crop in Asia and the Pacific. It is a staple food in India, Indonesia, and parts of the Philippines where it is also an important component of livestock feed. In Thailand, maize, grown mainly for export, yields more than 2 tonnes/ha, but is showing a decrease and, as most is grown in newly-cleared forest areas, the trend is likely to continue unless corrective steps are taken. The yield of maize is less than one tonne/ha in Indonesia.

Research on cropping systems is relatively new and needs to be strengthened. The addition of lime to highly acidic soils (pH 4.2-4.6) has increased yield per ha by 20 to 50% in India and the Philippines. Intercropping with pigeon pea is common in certain parts of India; in high-rainfall areas, intercropping of soyabean gives an additional yield of 0.2 tonnes without affecting the yield of maize. In North India where sequence cropping of maize and wheat is common, water harvesting and recycling not only stabilize maize production but also ensure good wheat crops.

Rainfed farming systems have received increased attention in recent years. The emphasis is on irrigation, fertilizer and pesticide technologies to obtain the maximum production in the most favourable environment. These technologies are highly capital and energy-intensive. Stability of production in unfavourable years and maximum production in favourable years should be the goal of farmers in rainfed areas. To reduce risks, the farmer should grow a number of upland crops, e.g. corn, cassava, food legumes, kenaf, cotton. So far, even in the uplands, the emphasis has been on rice. A concerted research and development effort should be made to improve the production and efficiency of cropping sytems based on upland crops other than rice.

2.4 NON-AGRICULTURAL USES OF WATER

While the major use of water in the region is for irrigation, it is also used for domestic and industrial purposes (including mining), hydropower, navigation, recreation and waste disposal. Development schemes have been undertaken on varying scales, from the construction of roof catchment storage tank systems to provide domestic supply for villages in rural Asia and the Pacific, to huge multipurpose dam/reservoir projects. The demand for good-quality water has increased in the past few years and will continue to accelerate because of increasing agricultural development, industrialization, urbanization and per caput incomes. (1)

During 1972-78, hydropower generating capacity increased by 27% to meet rapid industrial and urban development. Hydropower accounts for only about 18 to 19% of the total electric power generated in the Asia and Pacific Region, although it is the primary source of power in Afghanistan, Nepal, and Sri Lanka. The total hydropower potential of the region is not a practical representation of likely development potential, since Nepal, for example, with a potential 1 000 times greater than the national demand, would have to export electricity, and its ability to do so is questionable. Most countries have exploited less than 25% of their hydropower potentials.

China has probably the most ambitious hydropower development plan in the region. Several large projects are being planned, including "The Three Gorges", with potential generating capacity of 25 000 to 30 000 MW, four to five times larger than any of the world's power plants. If implemented, the project would inundate more than 120 000 hectares of farmland and displace more than one million people. Other planned

projects total over 20 000 MW. China also relies on small or mini-hydro plants for rural oower in remote areas. From 1970 to 1978, 84 500 mini-plants were constructed with, in most cases, installed capacity of less than 12 MW.

Some countries (e.g. India and Thailand) face the difficult task of exploiting international rivers to increase hydro-generating capacity. Of the more than 200 internationally-shared river basins in the world, 40 are situated in the region. A review of the conservation needs and problems of these river basins is urgently needed.

In countries in the arid and sub-arid zones, water supplies are intermittent presenting a serious health problem. Many of the Pacific islands have no running water; others have little surface water. A large-scale groundwater exploration and development programme undertaken by the United Nations, together with some bilateral aid projects, have resulted over the past 15 years in benefits for 57 developing countries, including the island nations of Fiji and Samoa. The hydro-geological characteristics of the islands vary considerably and there is limited knowlege of groundwater resources. Emphasis is now being placed on re-use of water in many of these islands.

The problem of drinking water in Asia and the Pacific, as elsewhere, is one of access to clean supplies. The proportion of clean potable water in 1967 was only about 5% of the total. A projection of the pattern of water use up to the year 2000 shows that the proportion of this potable water could increase to 6%. (2) Urban populations have usually more access to clean drinking water than the rural populations. In 1980, less than 20% of the rural communities in some countries of the region had access to clean water.

2.5 ENVIRONMENTAL EFFECTS OF WATER USE

The development and management of water resources should be based on sound environmental and health considerations. Water development projects can result in an increase in the incidence of certain water-associated diseases, such as gastro-enteritis, malaria and schistosomiasis, or poliomyelitis and hepatitis.

Another problem, frequently overlooked in the past, is the effect of water-related projects on natural habitats which may include wildlife habitats of international significance. The fact that, in many cases, the effects appear to have small economic significance has undoubtedly been a factor in the lack of importance given to such issues. This, once again, points to the need for improved techniques for multi-objective appraisal of proposals.

During the last decade, increased agricultural development, industrialization and urbanization have necessitated the use of more water, causing deterioration of the water resources. In the island countries of the region, as industrialization and tourism increase, so does the demand for water. Without effective waste management, the fragile "freshwater lens" of such islands are polluted, and frequently coral reefs are irreversibly damaged. The increasing use of agricultural chemicals may also contaminate the freshwater lens causing health hazards. Excessive withdrawal of water from the lens will result in salinity and loss of water, which may take decades, or even centuries, to replenish.

In other areas, the uncontrolled use of groundwater for urban needs has resulted in depletion of supplies, salinity and land subsidence. In Bangkok, where the total groundwater pumping rate exceeds one million

cubic metres per day, the water table is being lowered at a rate of 2.5 to 3 cubic metres a year. This is resulting in widespread land subsidence, at an average rate of about 5 cm/year and maximum rate of 10 cm/year. Since Bangkok is only 0.5 metres above sea level, tidal flooding can be expected to increase as the land subsides.

The pollution of water from domestic and industrial sources poses public health problems. The traditional water supplies of some major cities in the region, such as Seoul and Bangkok, have become so polluted that water must be conveyed long distances from upstream sources, thus significantly increasing the cost. In the Philippines, a National Economic and Development Authority report states that some 680 000 cases of water-borne disease occurred in 1975. Yields were reduced by about two thirds from the 44 oyster and tahong fish farming areas because of pollution.

Treatment of water supplies and industrial wastes is increasing, but accelerated efforts are needed, especially in the management of domestic wastes. The International Drinking Water Supply and Sanitation Decade (1981-90) was launched because of the critical need to improve water supply and waste management in developing countries.

Irrigation poses serious problems in water resource management: unnecessary water loss (50% or more), salinization, water-logging, alkalinization of soils, salt loading and salt concentration of return flows. These are caused by irrigating unsuitable soils, irrigating with highly saline water, or irrigating soils with poor drainage, high water table and high evapo-transpiration rates. The productivity of vast areas of agricultural land has been reduced as a result of salinization, waterlogging and alkalinization.

Water resource development, involving the construction and operation of dam/reservoir and irrigation systems, can cause a number of adverse impacts which may be felt long after the system is operational, and far away from it. These include: i) destruction or degradation of upstream watershed resources and subsequent adverse effects of easier access to remote areas; ii) public health problems and disease transmission, including schistosomiasis and malaria; iii) downstream soil and water degradation; iv) resettlement problems and (v) salinity in river basins.

As countries of the region develop, demand for water may exceed supply. In some cases, choices will have to be made whether to serve agricultural or industrial development. Mostly, however, the problem is less one of scarcity of water, than of more rational and better management practices. Watershed management ensures better yields of water, increased productivity from good agricultural land, and a reduction of pressure on marginal lands. As the demand for water increases, long-term policies reflecting the demand patterns will be required, which are consistent with the efficient use and better management of social and environmental elements.

(1) UNEP. Asia-Pacific Report, 1981. Bangkok: Regional Office for Asia
1982 and the Pacific.

(2) Ramana, D.V. An Overview of Environment and Development:
1980 Asia and the Pacific. Bangkok: UNAPDI.

(3) Aki, K. & Berthelot, R. Hydrology of Humid Tropical Asia,
1973 in Natural Resources of Humid Tropical Asia, Natural Resources Reseach XII, Unesco, Paris.

(4) United Nations. Report of the ESCAP Regional Preparatory Meeting
1976 for the UN Water Conference, Bangkok, E/CONF.70/4, Annex 3. 11 October 1976.

(5) Tapping the Ground Water Resource, in Indian Farming,
1982 May 1982, New Delhi.

(6) Maheswaran, A. Integrated Approaches to Water Resources
1982 Development in Rural Areas, in Environment and Development in Asia and the Pacific: Experiences and Prospects. Nairobi: UNEP.

(7) FAO. FAO Production Yearbook 1984. Rome.
1985

(8) United Nations. Proceedings of the Workshop on Efficient Use and
1979 Maintenance of Irrigation Systems at the Farm Level in China, Water Resources Series No. 51. New York.

(9) FAO. Rainfed Farming Systems in Asia and the Pacific:
1982 Cropping Patterns in Agro-ecological Zones of Southeast Asia. Bangkok: FAO Regional Office for Asia and the Pacific.

(10) FAO. Agriculture: Toward 2000. Unpublished data covering 15
1981 Asian countries. Rome.

(11) FAO. Report on the Agro-ecological Zones Project. World Resources
1978- Report, Vols. 1-4. Rome.
1980

3. CLIMATE AND AGROCLIMATIC SUITABILITY

3.1 MAJOR ELEMENTS OF THE REGION'S CLIMATE

The climatic features of humid tropical Asia are determined by its location in the low latitudes, the high insulation and size of the landmass, with a vast ocean to the south and east. The dominant climatic features are the monsoons: the southwest monsoon in summer and the northeast monsoon in winter.

Although the causes of monsoons are not well understood, the primary factor is the distribution of land and seas in and around the region. The humid tropics of Asia, dominated by the continental masses to the north, provide the best illustration of the seasonal variation in temperature and atmospheric circulation resulting from land-sea contrasts. Central Asia has a continental climate which shows great differences between summer and winter temperatures, forming a large high-pressure zone in the winter and a low-pressure zone in the summer. The temperatures over the continent are far greater than those over the sea surfaces during summer, and in winter the situation is reversed.

3.1.1 The Indian monsoon (1, 2)

As the inter-tropical convergence zone moves northward with the advance of summer, the temperature over the land rises so that, by the end of May, the mean daily maximum temperatures can reach more than 41°C over the desert in Northwest India and adjoining areas of Pakistan. Temperatures over 47°C are not infrequent. The resulting low pressure system causes the easterly trade winds to change direction and become southwesterly and westerly upon crossing the equator, where they pick up copious amounts of moisture from the Indian Ocean.

After entering the Arabian Sea and the Bay of Bengal, they reach the west coasts of India and Burma as southwest monsoons. The monsoons start in early summer in Sri Lanka and South India and later in North India and Pakistan. The progressive changes in the temperature and pressure fields culminating in the abrupt onset of the summer monsoon toward the end of May, its sway over South Asia for the next four months, and its retreat toward the end of September, constitute a large-scale meteorological phenomenon which has no equivalent elsewhere in the world.

The entire character of the weather changes dramatically as the southwest monsoon bursts and gives much-needed relief from the sweltering heat of May and June. The monsoon, bringing rain to the dry and parched lands, affects agriculture in a substantial way. The northward progress of the monsoon is watched with considerable interest and anxiety. The southwest monsoon accounts for 80 to 90% of the annual rainfall over a predominant portion of India.

Mountain ranges aligned against the path of the prevailing moist winds play a vital role in rainfall patterns and form climatic barriers dividing regions of markedly different weather patterns.

The southwest monsoon over the Indian subcontinent is not a steady phenomenon. The monsoon pulsates with a series of depressions originating in the Bay of Bengal and moves in a westerly to northeasterly direction across Northern and Central India. Occurring at the rate of 3 or 4 per month during the monsoon season, these depressions divert the humid currents into the central and northwestern areas of India, providing a more even distribution of rainfall. In years when their frequency is low, rainfall is confined to the mountain ranges, while the plains of Northern and Central India suffer from drought. The high rainfall areas lie in the northeast and on the west coast of India and Sri Lanka and the coastal areas of Burma. A narrow strip along the Himalayas also receive considerable rainfall.

During the southwest monsoon season, the areas which receive normal rainfall in excess of 1 000 mm are also those where variability is low (less than 30%). The scanty rainfall areas, on the other hand, have higher variability. In West India, the variability in rainfall can be from 40 to 60%. The interior of the southern peninsula suffers the largest variation (40 to 100%). However, during the northeast monsoon season, the interior areas of the southern extremity of the peninsula experience less variable rainfall (less than 40%). Even on a monthly basis, variability of rainfall is large over West India and the peninsular semi-arid tracts.

These uncertainties in precipitation during the principal monsoon season have significant economic consequences. Droughts and floods represent extreme fluctuations in the precipitation pattern. One of the causes of drought in the monsoon season is what is called "breaks", which last from a few days to two weeks and sometimes longer. A prolonged break often results in partial or complete failure of crops over large areas. While droughts and floods throughout the country are rare, there have been no years in which floods have not occurred in some parts of the country and droughts in other parts.

By mid-September, the southwest monsoon has withdrawn, allowing the northeasterly air current to assume full sway over the subcontinent and adjoining areas by January. The northeast monsoon brings rains over Southeast and South India from November to January and some rain also to North India, Northwest Pakistan and East Afghanistan.

The two transition seasons, April-May and October-November, are the periods of tropical cyclones in the Bay of Bengal and the Arabian Sea. An average of three to four severe cyclonic storms may form in the Bay of Bengal in the pre-monsoon period, and about six in the post-monsoon season. The Bay of Bengal and the Arabian Sea are unique regions of the world where tropical cyclones form at very low latitudes close to the equator. Some of the storms crossing the coast cause tidal bores and storm surges which inundate coastal areas, causing considerable loss of life and property. The cyclone which struck the coast of Bangladesh in November 1970 took over 200 000 human lives, while another which struck the Orissa coast in October of the same year accounted for 10 000. Both caused damage to property running into billions of rupees.

3.1.2 Central Asia (2)

The main characteristics of the climate of Central Asia are determined by the large size of its land mass, its geographical position vis-à-vis the tropical weather systems, and the presence of the immense continental mass of Northern Asia. Most of Central Asia has temperate or subtropical climate, with high mountains and desert plateaux predominating in its northwestern part.

In the temperate zone, covering North China and Mongolia, the climate is influenced by the northern polar front. During winter, the continent cools strongly and this, coupled with the inflow of descending air masses in the subtropical zone, cause a high-pressure zone to develop. This front brings cold, dry winters. The subtropical zone, on the other hand, is influenced by the northeast monsoons in winter, which bring a little precipitation to the far southeastern parts, but dry climates elsewhere.

In the summer, most of Central Asia is influenced by the southeast monsoons from the Pacific Ocean, which bring tropical typhoons to the coast of China, and heavy rains elsewhere. The temperate zones receive less rain because of the obstruction by the Ch'in Ling and other mountain ranges, thus creating steppes and deserts on the high plateaux.

The average annual rainfall in China is 600 mm, but there is a large regional variability. East China, because of its proximity to the Pacific Ocean, may receive up to 2 000 mm of rainfall, while the northwestern deserts may get less than 150 mm. Mongolia has an average of 220 mm of rain per year, with very cold winters and warm summers. Both the Republic of Korea and the People's Democratic Republic of Korea are located in the subtropical zone and are characterized by mild winters and long, warm suumers. The Republic of Korea receives an average annual rainfall of about 1 160 mm.

3.1.3 The Malaysian-Australian monsoon (2)

Unlike India, Southeast Asia is more affected by the winter monsoon and its surges. Southeast Asia and Northern Australia are combined in one monsoon system, differing from others due to the peculiar and somewhat symmetrical distribution of land masses on both sides of the equator. The substantial water masses between Asia and Australia have a moderating effect on atmospheric temperatures, weakening the summer monsoon. The many islands of Indonesia and the Philippines provide a variety of topographical effects. Typhoons that develop within the monsoon air bring additional complications.

The northern limit of a typical monsoon is about latitude 25^{o}N. In South China and the Philippines, the easterly trade winds prevail in the winter period (October-April), to be replaced by the southwesterly winds in the summer period (May-September). These summer streams are shallow and bring rain only when subjected to considerable cooling along the steep windward slopes of the Phlippines and Taiwan.

The islands of the Philippines stretch north to south between 20o and 5^{o}N. Except for the east-central parts, the Philippines gets most of its annual rain from May to October. The percentage of yearly rain in this interval increases northwards. Like India and Bangladesh, the Philippines also has a serious tropical cyclone problem. Most of the typhoons and tropical depressions develop in the area between the Philippines and longitude 160^{o}E. They generally form during the period from May to November, with a maximum frequency of four in September.

In Viet Nam and Thailand, the summer monsoon is more strongly developed because of the wider expanses of overheated land. The southwesterly monsoon streams are thick and bring plentiful rainfall from May to October. Most of Lao, Kampuchea and Viet Nam get their annual rainfall in these six months. However, along the east coast and on the eastward slopes, more rain is brought by the winter monsoon. These parts have rain almost throughout the year.

Heavy rainfall does not generally occur in Thailand, as the country is sheltered from the summer monsoon by the Tennasermi ranges, and from the winter monsoon by the mountains of Viet Nam. The mean annual rainfall ranges from about 1 000 to 1 500 mm. During the winter monsoon, the weather is dry and cool. The summer is dry with moderate rainfall. The climate of Malaysia, on the contrary, is characterized by high humidity, abundant rainfall from both summer and winter monsoons, and little variation in temperature throughout the year.

The ocean expanses make the monsoon winds over Indonesia weak and the climate is generally hot and humid in all seasons. The northeasterly flow from Asia, which becomes northwesterly south of the equator, is laden with moisture when it reaches Indonesia, and brings cloudy and rainy weather between November and May. The wettest months are December in most of Sumatra, and January elsewhere. However, rainfall patterns are highly localized because of the mountainous character of most islands and the variety of topographical and geographical features.

3.1.4 Australasia (2)

Tropical climate dominates the lowlands of Papua New Guinea and most of the Pacific islands. Well over half of Papua New Guinea receives more than an annual 2 500 mm of rainfall. Two extensive belts receive over 5 000 mm a year. Temperatures are moderately high, with low seasonal variation. Frostless tropical highlands are found above 2 000 m, which carry a substantial population and are important crop-producing areas.

The Solomon Islands lie in the mobile and transient inter-tropical convergence zone. From about March to November, the islands experience steady southeasterly air flows, but during November, there is likely to be unsettled weather. Mean monthly temperature and humidity vary little, but rainfall is outstandingly varied due to the advent of cyclones between January and April. New Caledonia has an oceanic climate, with southeast tradewinds bringing rain for most of the year. Much of the rain is heavy and causes high stream flows. Temperatures are generally mild, but hot in summer (December to March).

The general pattern over the Pacific islands is of abundant, well-distributed rainfall. The broad pattern is interrupted on the larger high islands, where seasonal shifts in trade winds can give marked variations. Severe droughts lasting many months, with annual rainfall as low as 200 mm, may occur on equatorial islands such as the Gilbert, Phoenix and Line groups. These are, however, exceptional and most of the low islands have adequate rainfall, well distributed throughout the year.

The tropical Pacific is sunny, despite its high rainfall. This is because much of the rainfall is from thunder storms which form and clear rapidly. Temperatures are characteristically high and uniform. Most of the tropical areas are subject to hurricanes or typhoons, accompanied by destructive winds, torrential rains and high seas. In each cyclone, however, the belt causing damage is narrow, and the benefits of heavy rains over wide areas are substantial.

3.2 AGROCLIMATIC SUITABILITY FOR CROP PRODUCTION (3, 4)

Soil, climate and crop data, such as temperature, wind and sun patterns, soil moisture and condition, evaporation and evapotranspiration, are extremely important for agricultural planning. Understanding the interaction of climate, soils and management parameters in relation to

crops can help both in increasing yields and in expanding the annually harvested area. Such information, collected from a network of stations over a number of years, can be used to demarcate climatic zones and determine the complicated pattern of crop/weather relationships which would help in planning cropping patterns and deriving the maximum return from the land.

A period of scant rainfall, fatal to crops in one region, might be sufficient for growth in another. Plants use up the moisture in the soil, then suffer from lack of it if there is a drought. Drought has been defined as a condition in which the amount of water needed for transpiration by the plant and direct evaporation exceeds the amount available in the soil.

Although Southeast Asia and large parts of South Asia have a humid tropical climate, which implies excessive moisture, rainfall varies greatly from day to day, month to month, season to season and year to year, posing innumerable problems for farmers.

The humid tropics are characterized by isothermal conditions, which means that, unlike temperate areas, temperatures are generally suitable for crop production throughout the year. Total radiation in the humid tropics varies from relatively low values during the wet period to relatively high values during the dry season. While the net biomass production is largely a function of the total radiation received by the crop canopy, high total radiation is, unfortunately, negatively correlated with water availability, which determines the feasibility of year-round cultivation or the length of the growing period.

Irrigation has improved agricultural production tremendously, allowing crops to be cultivated during the period when total radiation is at its maximum. However, the areas covered by irrigation schemes are limited. In such circumstances, instead of adapting the natural environment to specific crops, it is possible to adapt the crops (or cropping patterns) to the prevailing environmental conditions, in particular to the seasonal availability of water.

The basic question before agricultural planners is therefore: to what extent can crop yields be increased and harvested areas expanded? The harvested area can be expanded by reclaiming areas under natural vegetation. However, rapid degradation of the natural fertility of the soil often takes place (e.g. because of erosion), leading to low and often disappointing yields. The annually-harvested area can also be expanded by cultivating more than one crop per year in the same area. The agroclimatic conditions of the humid tropics are often favourable for multiple cropping, but only if the water surplus during the wet season can be stored and used to supply crops during the dry season.

The seasonal availability of water is determined by agroclimatic and atmospheric conditions. Atmospheric parameters determine the amounts of water precipitated and evaporated. Soil characteristics determine the amount of water available by lateral movement over the soil surface and within the soil, and the amount of water that leaves through vertical percolation and lateral movement. In addition, the soil has the capacity to hold water against gravity.

Finally, the crop itself is also part of the water balance. Its characteristics determine the quantity of water absorbed through the root system and expended through transpiration. Each crop requires a certain arrrangement of growth factors for optimal development. Rice, for example, has been cultivated for thousands of years in river deltas on young, often rich, alluvial soils with a seasonal abundance of water.

Rice-growing areas are characterized by a 5-month rainy period, mean monthly temperatures of around 25°C and sunshine at approximately 25% of its potential. Yields are stable but moderate.

Agroclimatic research can help in tranferring knowledge from one region to another. The dry seeding of rice during the pre-monsoon period in Indonesia is a good example of how farmers have traditionally made use of available water. Rice seeds germinate in a moist soil when the first rains fall, and develop in later growth stages under submerged soil. By dry seeding, farmers can harvest their first crop one or two months earlier than if they had waited until the soil was completely inundated to transplant the seedlings. They can then cultivate a second, transplanted rice crop during the remainder of the wet period. Therefore, two rice harvests are possible, even in areas with a wet period of only 5 to 6 months. This cultivation pattern could be transferred to other regions with similar climatic conditions.

3.3 RAINFED CROP POTENTIAL IN SOUTHEAST ASIA (5, 6)

Crops can be classified into climatic adaptability groups by the charcteristics of their photosynthesis. Since these depend on temperature, it is the prevailing temperature which determines which crops can be grown. Four temperature-related crop groups may be identified.

i) Crops with an optimum temperature for maximum photosynthesis of 15° to 20°C, which are adapted to cool conditions (mean daily temperature 5° to 20°C). Among Asian crops, these include spring wheat, winter wheat, white potato, and highland Phaseolus beans.

ii) Crops with an optimum temperature of 25° to 30°C, which are adapted to warm conditions (mean daily temperature 20°C), e.g. paddy rice, cotton, sweet potato, soybeans and lowland tropical Phaseolus beans.

iii) Crops with an optimum temperature of 30° to 35°C, which are adapted to hot conditions (mean daily temperature more than 20°C), e.g. lowland tropical maize, sorghum and pearl millet.

iv) Crops with an optimum temperature of 20° to 30°C, which are adapted to moderately cool conditions, e.g. highland maize and sorghum.

Land in the major climatic zones can be classified by the length of the growing period. Annex Table 5, shows that 141.13 million ha, almost 16% of the total land area in Southeast Asia (the area with less than 75 growing days), is too dry or too cold for rainfed crop production. A further 22% (with 90-179 growing days) requires special measures for stable rainfed crop production. This means that 84% of the land area in Southeast Asia is climatically suitable for rainfed production (i.e. short, long and year-round humid growing periods, with no severe temperature constraints).

FAO has completed a project designed to ascertain the present and potential land use for the rainfed production of 11 major crops, at different levels of input. The methodology involved a computation of the different lengths of growing period when neither water not temperature were limiting factors. This climatic assessment was superimposed on the Soil Map of the World (2), thus providing a basic inventory of land in terms of agro-ecological zones. The results for Southeast Asia are shown in Annex Table 6.

The land areas suitable for one crop cannot be added to the land areas suitable for another crop. Estimates of the total extent of land suited to rainfed crop production in general can be arrived at by adding the maximum area suitable for production of some crop in each individual length of growing period zone in each major climate. The results for Southeast Asia are presented below. Data for Central Asia and the Pacific are in preparation.

Table 3.1 Land suitable for rainfed crop production in Southeast Asia

	Low inputs	High inputs
	--------(million ha)--------	
Very suitable and suitable	184.0 (20.5)	226.3 (25.2)
Very suitable, suitable and marginally suitable	281.8 (31.4)	271.0 (30.2)

Note: Figure in parenthesis show the results as a percentage of the total land area (897.6 million ha) in Southeast Asia.

Source: Ref. (6).

The area of potentially cultivable rainfed land for annual crops under low inputs, i.e. 281.8 million ha, is somewhat lower than the estimate of 331 million ha compiled from various country sources (FAO, 1979). This is because country returns included lands with a growing period of less than 75 days duration. The total extent of such lands in Southeast Asia is 94 million ha. Assuming that some 33% of this land is cultivable, 31 million ha could be added to the final figure. The study also assumes that half the Vertisol areas in zones with a growing period of less than 135 days are too heavy for cultivation. Of the 57.9 million ha, 23.9 million are in zones with a growing period of less than 135 days, and are in fact fully cultivated. This accounts for an additional 12 million ha of cultivable land. Add these two figures (31 and 43 million ha to the estimate of 281.8 million ha and the total of potentially cultivable rainfed land in Southeast Asia comes to 324.8 million ha.

Land-use data for Southeast Asia show that some 262.5 million ha are under annual crops. This means that the available land reserve for annual crops is 19.3 million ha (7.4%). Including the additional cultivable Vertisol area of 12 million ha increases the reserve to 31.3 million ha (11.9%). (It was not considered realistic to include areas with a growing period of less than 75 days because of their low and variable production potential). As estimates of cultivable land on a country basis are also available, the extent of land suited to crop production and land reserve can also be computed for individual countries.

In terms of the potential population-supporting capacity of the land, Southeast Asia poses a serious problem: 69% of the population live in countries that were critical in 1975 at low-level input. Food self-sufficiency will entail massive movement of food and building of infrastructure over vast areas.

3.4 WEATHER FORECASTING

Agriculture in the Asia and Pacific Region depends largely on the monsoons, and lack of water affects irrigation, power and industry. Reliable forecasting of the performance of a monsoon a few months ahead is of considerable value in planning agricultural production, stocking adequate foodgrain and planning relief measures. Hence there is a vital need for more research into long-range and medium-range forecasting. Crop monitoring and forecasting are already possible through an analysis of existing agro-meteorological data. These data can even be used to forecast outbreaks of pests so that measures can be taken to prevent crops from being destroyed. Environmental monitoring (including remote sensing) of natural resources should be closely linked to weather observations so that changes can be related to records of rainfall, temperature, humidity, wind, and sand or dust storms.

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(1) Koteswaram, P. 1974 Climate and Meteorology of Humid Tropical Asia, in Natural Resources of Humid Tropical Asia, Natural Resources Research XII. Paris: Unesco.

(2) FAO/Unesco. 1977-1979 Soil Map of the World. Vol. VII: South Asia; Vol. VIII: North and Central Asia; Vol. IX: Southeast Asia; Vol. X: Australasia. Paris: Unesco.

(3) Raman, C.R.V. A New Approach to Rainfall Climatology for Agricultural Planning, in Science Today. Bombay.

(4) Oldeman, L.R. & Frere, M. 1982 A Study of the Agroclimatology of the Humid Tropics in Southeast Asia. Rome: FAO.

(5) FAO/UNFPA/IIASA. 1982 Potential Population-supporting Capacities of Lands in the Developing World. Rome: FAO.

(6) FAO. 1980 Report on the Agro-ecological Zones Project, Vol. 4: Results from Southeast Asia. World Soil Resources Report No. 48/4.

4. FOREST RESOURCES

Forests make a valuable contribution to the rural economy and social conditions of the Asia and Pacific Region. A major problem in the region is the rate of removal of closed tropical forest cover for conversion to agriculture and shifting cultivation. During 1970-80, some 25 to 30 million ha of forest cover was removed from hills and uplands with steep gradients, or from land unsuitable for permanent agriculture. Deforestation has many adverse effects. It can destabilize water flow, cause silting of streams, reservoirs and irrigation works, deplete groundwater, intensify flooding, aggravate droughts and water shortages, degrade watersheds, and cause soil erosion, loss of arable land and reduced agricultural productivity.

Vital reservoirs, such as Tarbala and Mangla in Pakistan, Nizamsagar in India, Kaptai in Bangladesh and Ambuklao in the Philippines, have had their useful life significantly shortened because of sediment yield from mountain watersheds, caused by human pressure. It is estimated that some 2 400 million tonnes of silt are carried by the rivers of Bangladesh alone. In recent years, devastating floods and droughts in several countries in the region have been, at least in part, attributable to large-scale deforestation. The 1977-78 floods in the Indo-Gangetic plain affected 17 million ha of land and 65 million inhabitants, with a loss of 12 600 lives. Damage to crops, houses and public utilities was estimated at US $1 800 million. In 1979, a drought affected most of India and again in 1980 monsoon floods claimed some 2 000 lives and US $750 million in damages to property.

4.1 PRESENT SITUATION AND FUTURE OUTLOOK

A FAO/UNEP study (1) carried out in 1980 assessed the forestry resources of Tropical Asia and estimated that 445 million ha in the 16 countries covered by the study* (about 47% of the total surface) were under natural woody vegetation, including shifting cultivation. The countries with the greatest expanse of natural woody vegetation were Indonesia (158 million ha), India (72 million ha), Burma (53 million ha), Papua New Guinea (40 million ha) and Malaysia (25 million ha). Annex Tables 7 and 8 show respectively forest resources and annual rate of deforestation in these countries. China, which was not covered by the assessment, has 167 million ha of natural woody vegetation.

Unless otherwise indicated, the following data are taken from the above study.

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* Bangladesh, Bhutan, Brunei, Burma, India, Indonesia, Kampuchea, Lao, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Thailand and Viet Nam.

Table 4.1. Distribution of woody vegetation in some Asian countries

Sub-region	Million ha	% of region
Insular Southeast Asia	198	44
Continental Southeast Asia	123	28
South Asia	84	19
Papua New Guinea	40	9

Closed forests in Tropical Asia cover 305.5 million ha or 69% of the total area under natural woody vegetation. Closed broadleaved forests account for 292 million ha, of which only 192 million (66%) are productive, the rest being considered unproductive because of inacessibility or for statutory reasons (e.g. national parks). Six countries (Burma, India, Indonesia, Malaysia, Papua New Guinea and Philippines) account for some 90% of productive closed broadleaved forests of the region. (See Annex Tables 7 and 8). Similar data are not available for Central Asia.

Table 4.2. Percentage of closed forest to land area

	(%)
Papua New Guinea, Sabah, Sarawak	60
Brunei, Indonesia, Peninsular Malaysia	50-60
Burma, Bhutan, Kampuchea	40-50
Sri Lanka, Philippines, Lao, Viet Nam	20-40
India, Nepal, Thailand, China	10-20
Bangladesh, Pakistan	10

Productive closed broadleaved forests, not intensively managed, which have been logged over but not converted to non-forestry uses, cover 58 million ha (about one fifth of the total closed broadleaved forest area) of Tropical Asia. Indonesia, Malaysia and Philippines - which provide many of the tropical logs for international markets and domestic processing - account for 75%.

Table 4.3. Closed broadleaved forests of Tropical Asia

Country	Million ha	% of region
Indonesia	113.6	38.9
India	46.0	15.8
Papua New Guinea	33.7	11.6
Burma	31.2	10.7
Malaysia	21.0	7.2
Philippines	9.3	3.2
Thailand	8.1	2.8
Lao	7.6	2.6
Viet Nam	7.4	2.5
Kampuchea	7.1	2.4
Sri Lanka	1.7	0.6
Nepal	1.6	0.5
Bhutan	1.5	0.5
Bangladesh	0.9	0.3
Pakistan	0.9	0.3
Brunei	0.3	0.1

Open broadleaved forests in the region amount to 31 million ha and predominate in Thailand, India, Lao, Kampuchea and Papua New Guinea.

The area of coniferous forests in Tropical Asia is small (8.4 million ha); about two thirds are considered productive, essentially confined to the Himalayan belt in South Asia. There are also 5 million ha under bamboo (mainly in India, Viet Nam, Thailand and Burma), 73 million ha of fallows of closed and open forest formations, and about 36 million ha of scrub formations.

About 80-90% of tropical Asian forested areas are State-owned and under the control of forestry departments. In some countries, small areas of forest are owned by local bodies. Most Pacific island forests are not owned by the government but by clans and tribes. Small areas of privately-owned forest still exist, often scattered and in the process of conversion to other forms of land use. In China, since 1982, all forested areas come under the management of a national forest system.

Defining "intensive management" as the "controlled application of harvesting regulations, complemented by appropriate silvicultural and protective measures designed to maintain the productivity of the forests", the FAO study concludes that experience in intensive management is limited to a few countries, notably Burma, Bangladesh, India, Pakistan and Malaysia. Only a fifth of the productive closed broadleaved forests are intensively managed. Since the late 1960s, commercial exploitation, through concessions, has been guided largely by economic considerations, and prescribed silvicultural practices have received little or no attention. There is also a dearth of trained manpower at the local level.

The 300 million ha of closed broadleaved and coniferous forests in the region contain a standing volume (VOB) of 45 thousand million m3 or 149 m3/ha. Six countries account for 88% of the VOB (including conifers): Indonesia (20 858 milllion m3 or 46%), Burma 4 538 million m3 or 10%), Malaysia (4 499 million m3 or 10%), Papua New Guinea (4 441 million m3 or 10%), India (3 478 million m3 or 8%), and Philippines (1 754 million m3 or 4%). The national averages for "volume actually commercialized" of undisturbed closed broadleaved forests (an index of production from the point of view of timber exploitation), ranges from 14 m3/ha in Burma to 90 m3/ha in Sabah, i.e. from less than 10% to about 30% of the corresponding gross VOB.

The study estimated that by 1985, as a result of the conversion of forests to other uses, the area under closed forests would decrease from 305.5 million to 296.4 million ha, i.e., an annual deforestation rate (i.e. clearing for agriculture and other land uses) of some 1.8 million ha, mostly of closed broadleaved forests. There would be a consequent reduction in the growing stock of these forests, which could amount to more than 2 000 million m3 in a five-year period.

China is a major exception to the rule. In 1979, forest cover was only 8.6% of the total land area. By 1982, this had increased to 14.3%, due to a large-scale afforestation programme at both State and commune levels. (5) In 1982, China had 4.51 million ha of plantations.

An estimated 40 million ha were deforested in Tropical Asia during the last quarter century, whereas the cumulative area under plantation at the end of 1980 was estimated at only 5.1 million ha. India and Indonesia accounted for 4 million ha, or 78% of this total. Six other countries contributed more than 1 million ha: Philippines (300 000 ha), Viet Nam (204 000 ha), Pakistan (160 000), Bangladesh (128 000 ha), Sri Lanka (112 000 ha) and Thailand (114 000 ha). Some 2 million ha

(39%) out of a total of 5.1 million were replanted during the period 1976 to 1980; 42% of these were non-industrial plantations compared to only 24% prior to 1976. By far the most important industrial plantation species in the region is teak (Tectona grandis). Important high-yielding hardwood species are Albizzia falcataria, Calliandra calothyrsus, Eucalyptus spp., Gmelina arborea and Leucaena leucocephala. Among conifers, Pinus merkusii is the chief plantation species.

An analysis of plantation policies, programmes and projects, financed through domestic or international funds, estimated that the planting effort undertaken between 1981 and 1985 would remain at the levels set in the previous five years, i.e. about 2.2 million ha over the five-year period. (2)

There is likely to be increased emphasis on non-industrial plantations reflecting the importance attached to meeting growing fuelwood needs of rural populations. Out of nearly 1 million hectares of fuelwood plantations to be raised in the region during 1981-85 (compared to 884 000 hectares in 1976-80), 58% will be in insular Southeast Asia and 26% in South Asia. But the high prices prevailing for pulpwood and building poles, may distort the market against fuelwood production.

Timber species with longer rotations (60 years and over) are likely to be less favoured. There will be an increase in industrial plantations of high-yielding hardwood species, with short rotations, for pulpwood production and non-industrial uses. Plantations of softwood species, mainly to meet the long-fibre needs of the pulp and paper industry, will receive greater attention.

4.2 INDUSTRIAL WOOD PRODUCTION

In response to an increasing demand for timber by growing populations, recorded removals of roundwood in Asia have registered an average annual rise of nearly 3%, which is well above world average.
The most marked changes in the pattern of production and export of logs is in Indonesia. Log production there trebled in the past decade from 7.7 to 26 million m3 while exports during the same period grew from 4.3 to 19 million m3. Thus, Indonesia's share in the subregion's log escalated from 21 to 48% and exports from 17 to 51%. There has been increased domestic processing, especially of wood-based panels, as evidenced by a rise from 5 000 m3 in 1968 to 526 000 m3 in 1979. During the seventies, Indonesia emerged as the most important log producer in Asia and in the whole tropical world. (2)

There has been a significant decline in log production in the Philippines in the last ten years from 11 to 7 million m3, and export of logs fell dramatically from 9 to 1.8 million m3. In Malaysia, however, log production rose from 17 to 30 million m3 in a decade, mainly attributed to production in Sabah and Sarawak. (2) Thailand, from being a net exporter, became a net importer during 1977-79, due to depleted forest resources, a ban on exports and growing domestic demand.

The production of wood for industry in the region is expected to rise from 101 million m3 in 1979 to some 126 million m3 in 2000 (an annual average growth of 1.06%). South Asia would account for 64% of the increase, continental Southeast Asia for 20% and Viet Nam for 8%. The forests of insular Southeast Asia which hitherto constituted an important resource, with significant export surpluses, may actually see a steady decline in overall removals after the year 1985.

4.3 FUELWOOD (3)

The output of wood for charcoal-making in 1980 in Asia and the Tropical Far East* was 570 million m3, or 86% of total removals. Fuelwood provided more than one third of total energy consumption. In Kampuchea, Lao, Nepal and Viet Nam, fuelwood provides more than three quarters of energy supply.

In rural areas, domestic consumption is preponderant. In the cold, lofty Himalayan countries (Afghanistan, Bhutan, Nepal, Northwest India), the need to keep warm increases energy requirements, which are two or three times greater than in the warm tropical zones, woody material representing almost all the energy resources.

In urban areas, population density makes open-air cooking difficult, resulting in less woody material being used (15-20% of energy consumption). This poses problems for the urban poor, whose purchasing power is insufficient to cope with the costs of commercial energy (oil, electricity, gas, coal).

Sources of fuelwood include national forests, forest plantations, fuelwood plantations and natural woody resources such as row plantations, hedges, village woodlots, orchards and trees scattered over arable land. In Asia, natural woody resources are important for domestic use, in particular as raw material for energy.

The annual volume of fuelwood from plantations is extremely low, except in China and the Republic of Korea, where reforestation is already providing the population with a considerable amount of fuelwood. In China, the total area planted each year is reported to exceed the area harvested. Of the 30 million ha of plantations since 1949, 2.1% are used for fuelwood and 80% for timber and bamboo. (5)

Table 4.4 Volume of fuelwood from plantations

	Million m^3
Countries of South Asia	31
Lowland, hill and delta countries of Southeast Asia	15
Closed forest countries in Southeast Asia	0.7
South Korea	20

Woody residues from agriculture and industry are also used for energy. About 30% of the volume of lumber and industrial wood ends up as waste (sawdust, shavings, etc.). Half of this can be used as a source of energy.

Agricultural residues are an important resource in Asia. The various types are listed in Table 4.5.

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* Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka, Burma, Kampuchea, Lao, Thailand, Viet Nam, Indonesia, Malaysia, Philippines, Papua New Guinea, Republic of Korea.

Table 4.5. Agricultural residues as source of energy

Type of residue	Equivalent woody material per tonne of product
	(m^3)
Rice husks, groundnut shells, coconut shells, sugarcane bagasse	0.25-0.3
Maize, sorghum, castor beans, cottonseed	1
Cassava, kenaf, natural rubber	4
Jute, hemp	2.0-2.5
Coffee	8
Miscellaneous	0.2-0.5

(Note: Account has been taken in the estimates of the need to return to the soil 50% of the residues in order to maintain the recycling of organic matter.)

The overall fuelwood balance in the region in 1980 is given in Table 4.6.

Table 4.6 Overall fuelwood balance 1980

Country	Level of need	Supplies	Average balance
	------------------m^3/inhabitant/year	------------------	
Category 1	0.3 - 0.5	0.02 - 0.03	- 0.38
2	1.3 - 1.8	0.22 - 0.26	- 1.31
3	0.2 - 0.7	0.16 - 0.20	- 0.27
4	0.3 - 0.9	0.24 - 0.28	- 0.34
5	0.5 - 0.9	0.75 - 0.80	+ 0.08
6	0.9 - 1.3	1 - 5	+ 2
Korea Rep.	0.3 - 0.9	1	+ 0.4

Category 1. Desert and sub-desert zones, usually sparsely populated and with scanty forest resources (West Pakistan, Baluchistan Mongolia and West Afghanistan)

Category 2. High mountain zones, more or less heavily populated with limited and/or inaccessible forest resources (high mountain areas of the Himalayas, Northeast Afghanistan, Northwest India, North Nepal).

Category 3. Densely-populated zones of regions not climatically favourable to forests, which cover only a limited area [plains and valleys of the North Indian subcontinent - East and

Northeast Pakistan (Indus Valley), Northwest and North India (Gujarat, Rajasthan and the Ganges Valley), and South Nepal].

Category 4. Densely-populated zones situated in regions climatically favourable to forests, which have been mostly cleared [the Indian Peninsula (Deccan), with the exception of the Northwest part (Orissa and Madhya Pradesh), Sri Lanka, Bangladesh, China and the heavily-populated zone of Southeast Asia: Central Thailand, coastal plains and deltas of Viet Nam, Java and the central Philippine islands].

Category 5. Forest zones with a rapidly-growing population, leading to rapid extension of clearing [the Indian States of Orissa and Madhya Pradesh, lower Burma, Northwest Sumatra, the interior of Viet Nam, North Philippines (Luzon), South Sulawesi and the Sunda Islands of Indonesia].

Category 6. Closed-forest zones with large forest resources and usually a small population [all the northern hilly and mountainous regions of continental Southeast Asia (Bhutan, Northeast India, North Burma, Lao, upper Thailand and Kampuchea), and the little-populated areas of closed forest of insular Southeast Asia, Malaysia Peninsula, Southeast Sumatra, Borneo, Mindano, North Sulawesi, the Moluccas and New Guinea].

In most of the countries listed above, fuelwood consumption is often greater than the level of supply compatible with sustained production. Hence, there is almost always over-cutting of wooded zones, resulting in degradation and decreased productivity of the wood capital. In many places there is acute scarcity, for which the people try to compensate by making maximum use of agricultural residues, thus depriving soils of organic matter.

In the mountainous areas, there is even greater destruction and degradation of forests than in the plains and tablelands, resulting in serious erosion. Where there is acute scarcity, economies are often made in heating, leading to an increase in mortality, particularly among old people and children.

The number of urban dwellers affected by energy shortages is considerable. Towns situated in rural areas with an energy deficit obviously suffer acute scarcity. Towns in rural areas with a balance or a surplus of energy are better placed, but the cost of transporting rural energy materials (wood, plant residues) can still lead to conditions of acute scarcity for the urban poor. It is unlikely that any appreciable change will occur in the share of woody material in domestic energy use by the year 2000. At most, there may be a slight increase in the percentage of commercial energy.

Table 4.7 shows the estimated fuelwood balance in the year 2000 for the categories described in Table 4.6. For Category 1, acute scarcity will continue, owing to degradation of the vegetation, making it increasingly difficult to obtain sufficient woody material. For Categories 2,3 and 4, the fuelwood deficit will worsen and almost all existing forest resources will become practically non-existant.

Zones in Category 5, which in 1980 maintained a balance between supply and demand, will be in deficit by 2000. Those living near uncleared forest formations will be able to meet their energy requirements without difficulty, but the heavily-populated rural regions, far from forest borders, will have to over-use all the woody resources available

(farm woodlots, forest fallows, agricultural residues) in order to cover their needs, resulting in environmental degradation. Category 6 as a whole will remain in a satisfactory condition, although the average supply will decrease by practically half.

Table 4.7 Wood balance foreseen for the year 2000

Country	Level of needs*	Supplies	Average balance
	m^3/inhabitant/year		
Category 1	0.3 - 0.5	0.01 - 0.02	- 0.4
2	1.2 - 1.7	0.10 - 0.14	- 1.38
3	0.2 - 0.7	0.14 - 0.18	- 0.3
4	0.3 - 0.85	0.19 - 0.23	- 0.4
5	0.5 - 0.85	0.45 - 0.50	- 0.2
6	0.85 - 1.20	0.70 - 4	+ 1.3
Korea Rep.	0.25 - 0.80	0.96	+ 0.4

* Reduced by 5%, as compared to 1980.

4.3.1 Suggested solutions

Acute scarcity. In 1980, an estimated 31 million people in the region suffered acute fuelwood scarcity; of these, 29 million were rural. This group includes:

1. Populations of desert and sub-desert zones (Category 1), estimated to be 9.5 million rural people, mainly nomadic shepherds, inhabiting an area of 88 million ha. Fuelwood suplies meet only 6% of their requirements. People overcut the vegetation and the situation grows ever worse. There is no large-scale forestry solution. All that can be done is to establish plantations around watering points, with the aim of providing livestock with additional fodder, providing the people with some fuelwood, and stabilizing and protecting the environment. But this will be quite insufficient to resolve the problem throughout the area.

2. Populations living in the Himalaya (Category 2), where 28.5 million rural people need considerable fuelwood supplies because of climatic conditions. The theoretical supplies are only 12% of needs. These needs, however, are in addition to the considerable requirements for other forest and fodder products also met by the same forest vegetation. People are therefore forced to over-cut all the available woody resources, leading to ever more rapid degradation of soil and vegetation. This situation will inevitably worsen over the next 20 years. Action is absolutely necessary to halt the process of soil degradation and erosion. Trees must be incorporated into farming systems and a certain forest cover maintained. Fuelwood plantations alone will not, however, satisfy all domestic energy needs.

3. The urban poor will also face considerable deficits. It is impossible to assess how many people are involved, but it is almost certainly several thousand million. Even assuming that their needs are small, their inability to afford commercial energy places them in a situation of acute fuel scarcity, often in addition to shortage of food. Here the problem is not one of forestry needs, but of social and economic needs.

Deficit. The number of people suffering from a fuelwood deficit in 1980 was estimated to be 832 million, 710 million being rural. Deficits occur in rural areas where supply compatible with sustained production is below requirements, but where people generally manage to meet their needs by overcutting the existing wood and plant resources. This group includes:

a) Populations living in rural areas with a climate unfavourable to forest vegetation (Category 3). These people (288 million) lead a frugal existence. Average wood and olant fuel suppy meets 40% of average needs, although in some places, supplies meet only 20% of needs. This leads to over-use of resources and to degradation of soil and vegetation. The size of the populations concerned makes any forestry solution of limited value. The Governments of Pakistan, India and Nepal are doing everything possible to protect and manage natural vegetation, but conditions limit yield capacity.

b) Populations living in rural areas with a climate favourable to forest vegetation (Category 4). These 412 million people, whose way of life is similar to those referred to above, have slightly higher wood and plant fuel requirements, owing to the smaller amount of dung available and the more humid climate. Average supply meets 30 to 90% of needs. Here, too, there is over-use of the resources. A favourable climate makes it possible to reduce the deficit by establishing forest plantations; but the scarcity of unused productive land in these over-populated zones excludes large-scale reforestation. Efforts should therefore concentrate on integrating trees with agriculture and developing small family or community plantations. Assuming a yield of 12 m3/ha/year of fuelwood (after 6 years), 25 to 30 ha would be enough to provide much of the fuelwood needed by 100 people.

Potential deficit. A total of 161 million people in the region are in a potential-deficit situation, 147 million of whom are rural. This group includes rural populations living in zones largely covered by closed forest, but where deforestation is growing as land is cleared for crops, and the fuelwood supply per inhabitant usually exceeds requirements (Category 5). But the growth in population and the decrease in forest resources mean that in many places there will be a fuelwood deficit by 2000. To compensate, people will over-use resources, resulting in progressive impoverishment of the wooded zones and, in particular, of the forest fallows, which will no longer be able to fulfil their functions.

Measures will have to be taken now to ensure that

a) forest lands are settled in accordance with sound land-use planning which provides for conservation of fuelwood zones; and new agricultural techniques developed, aimed simultaneously at increasing production, stabilizing agricultural land and conserving trees;

b) the maximum amounts of woody products are recuperated in order to avoid the wastage that now occurs during clearing;

c) plantations are established as the agricultural frontier advances, without making them so extensive as to be incompatible with their high unit cost. Priority should be given to community and farm plantations and the use of agro-silviculture technques.

4.4 FORESTRY FOR RURAL DEVELOPMENT

The World Conference on Agrarian Reform and Rural Development (4) stressed that forestry activities were essential for broad-based rural development. Forestry contributes to rural development by maintaining the ecological balance, increasing the supply of products and generating employment, especially for the landless.

There is considerable potential for introducing trees on land conventionally seen as strictly agricultural. The objective is not only to increase the supply of wood and ease pressure on forests, but also to contribute to food production, whether directly by fruit and fodder, or indirectly by providing shelter, restoring nutrients from deeper layers, or increasing nitrogen fixation. Trees may be introduced in many ways, from occupying strips of land not used for crops to mixing them with agricultural crops. Annual crops can be alternated with tree fallow. Trees thus used can produce products such as timber, poles, fuelwood, fodder and food. (2) These are the main principles of "agroforestry".

Mixtures of trees and agricultural crops can occur in either intercropping or multiple cropping systems. Indigenous agroforestry practices can make tropical systems highly productive. Yields may be 20 to 50% higher than for the same crops grown separately, and are greatest when annual crops are mixed with perennials, including trees.

Several improved varieties of *Leucaena leucocephala* (Ipil Ipil) are a rich source of fodder and fuel. Trials in India with giant varieties showed that fodder yields of over 100 quintals/ha/cutting could be obtained even on relatively poor soils using light irrigation. In less than four years, the trees grew to a height of over 10 m and yielded 200 tonnes of wood per ha. Even in areas with less than 400 mm annual rainfall and no irrigation, the average height was 9.5 m. Another Asian tree that can produce both fodder and fuel is *Calliandra calothyrsus*, which in Indonesia grows 2.5 to 3.5 m in six to nine months. After a year, these trees can be harvested for fuelwood, or their edible foliage and fruit used for animals.

Given this potential, several countries have been giving increasing support to community forestry. In the design of plantations, monocultures of exotic species are viewed skeptically, while there is a positive bias toward multiple use and species-mixing, based on local needs. More farmers are setting up plantations of tree crops on private farmland.

Wood will remain an important housing material in rural areas of Asia and the Pacific, and most rural people will continue to depend on fuelwood as their primary energy source. Forestry policies in the region should be directed toward alleviating poverty through rural development which integrates the productive, protective and social objectives in forestry. The social goal of equity could be used to reinforce a strategy of growth based on active and voluntary participation of forest communities.

A good example is China's "Four Sides Forestry Programme". Communities are encouraged to plant trees around fields, along rivers and roads, and in association with their crops. Soil conservation techniques, such as check dams, terraces and micro-catchments, have also been developed. (5)

(1) FAO/UNEP. Forest Resources of Tropical Asia. Tropical Forest
1981 Assessment Project. Rome: FAO.

(2) Rao, Y.S. & Chandrasekharan, C. The State of Forestry in
1983 Asia and the Pacific, in Unasylva, Vol. 35, No. 140.
Rome: FAO.

(3) FAO. Fuelwood Supplies in Developing Countries. FAO Forestry
1983 Paper No.42, Rome.

(4) FAO. Report of World Conference on Agrarian Reform and Rural
1980 Development, Rome 12-20 July 1979.

(5) FAO. Forestry in China. FAO Forestry Paper No. 35. Rome.
1982

5. WILDLIFE RESOURCES

5.1 IMPORTANCE OF WILDLIFE RESOURCES

Besides its aesthetic and genetic value (see Chapter 8), wildlife is a source of food and medicine, as well as a source of income (through tourism or export of wildlife and its products) for many developing countries.

The International Consultation on Wildlife Resources for Rural Development in Asia and the Pacific, organized by FAO in Hyderabad in 1980, (1) encouraged the reorientation of policies relating to the promotion, conservation and utilization of wildlife resources, primarily to meet the needs of rural people. People living on the fringes of forests, for example, have a direct interest in wildlife. But their cooperation in implementing plans for conservation and rational utilization of wildlife will be forthcoming only if they know that they themselves will benefit.

The value of wildlife as a source of food for subsistence populations has often been under-estimated because of lack of data. Wild animals still make a substantial contribution to the nutrition of certain communities in India. About 10 to 20% of the food intake of tribes in India is collected from the forest. In times of scarcity, wildlife, including plants, can constitute as much as 90% of their diet. One tribe annually harvests 2 180 kg of animal biomass per family, providing 57 grammes of protein and 850 calories per person, meeting total protein requirements and over one third of the calorific requirements. (2)

Wild animal products are extensively used as sources of medicine, particularly in China, India and Viet Nam. More than 100 kinds of Chinese medicine contain deer products. The Chinese have also succeeded in breeding minks and muskrats on a wide scale. Perfumes and perfume fixatives are manufactured from musk deer, musk cat, sperm whale and musk beaver.

In some countries (e.g. Nepal), tourists to national parks constitute a major source of revenue, although the benefits do not always filter down to the communities around the national parks. Wildlife tourism is steadily growing in popularity in India, which has several national parks. In some areas, "Project Tiger" reserves have been combined with wildlife sanctuaries that are open to tourists.

5.2 DEGRADATION OF WILDLIFE RESOURCES

The Red Data Book of the International Union for the Conservation of Nature and Natural Resources (IUCN) defines "endangered species" as those in danger of extinction if conservation measures are not taken. "Vulnerable species" are those likely to move into the endangered category in the foreseeable future. A third category, defined as "rare", has small world populations which, although they may not at present be endangered or vulnerable, are nevertheless thought to be at some risk.

There are at least 300 endangered mammal species in the Asia and Pacific region, of which 121 are ungulates, 114 carnivores, 30 primates, 25 marsupials/monotremes, and 10 small mammals. The number of endangered species in a country is roughly proportional to its size and ecological diversity. The majority of the region's large grazing animals are included in The Red Data Book, the only exceptions being sambar (Cervus unicolor) and barking deer (Muntiacus muntjak), which adapt well to secondary forest and distributed habitats.

Carnivores, such as big grazing animals, which need large areas of well-protected habitat for their survival, feature prominently in the endangered list. The only large carnivores not on the list are the Malayan Sun Bear and the Dingo. For only a few species are sufficient data available to make accurate estimates of their populations. India, with 27 threatened mammalian species, ranks second to the United States and first among the fifteen countries of the oriental region in the number of threatened mammals listed in the Red Data Book. Indonesia (16) occupies second place, while Nepal and Pakistan (12 each) are jointly third. It is estimated that the Asia and Pacific region may lose about one million species of plants and animals by the year 2000, including many whose existence is still unknown to science.

5.3 HABITAT PROTECTION

In most cases, the problem of endangered species cannot be separated from that of endangered habitats. Human activity has destroyed forest ecosystems which were once the exclusive domain of wildlife. Of particular concern are tropical rainforests and mountain forests which harbour a rich diversity of flora and fauna. Open grasslands, productive habitats for the large grazers, have also become degraded through over-use, coupled with drought. Habitat conservation - including the establishment and management of national parks, protected areas and biosphere reserves - is the critical element in wildlife conservation. Annex Table 9 lists the national parks and protected areas in the Asia and Pacific Region.

While legislation for protected areas is adequate, law enforcement is not and can be a major constraint in improving wildlife management. Since many of the problems have an international component, international legislation is becoming increasingly important. There are four main international conventions - the Wetlands Convention, World Heritage Convention, Convention on International Trade in Endangered Species of Flora and Fauna (CITES), and Migratory Species Convention.

A major objective of protected areas is the maintenance of species and ecosystem diversity, but the listing of protected areas by country provides little information on how effectively natural ecosystems are being conserved. Biogeography (the science of distribution of species and ecosystems) determines whether all types of ecosystem are being conserved, but, given that less than half the world's species have been scientifically described, it is unrealistic to expect mapping of individual species to become a workable tool in sufficient time to be useful.

A compromise solution has been worked out for terrestrial eco-systems. The world is divided into eight realms (continent or sub-continent-sized areas with unifying features of geography, flora and fauna). The realms are further divided into 193 provinces, defined by significant differences in flora, fauna or vegetation structure. Each province is characterized by one of the world's 14 biomes (major regional ecological communities of plants and animals extending over a large

natural area). Biome coverage gives an indication of how well the major ecological formations are protected, though there is of course considerble variation within each biome. (3)

The Indomalayan realm contains 572 protected areas (27.57 million ha), the Oceanian realm, 54 (4.13 million ha), and there are 36 (1.47 million ha) in the Palearctic realm.

Table 5.1 Ecological coverage of protected areas in Asia and the Pacific

Biome	Biogeographical realm					
	Indomalayan		Oceanian		Palearctic	
	(a)	(b)	(a)	(b)	(a)	(b)
1. Tropical humid forests	122	4.09				
2. Subtropical/temperate rainforest/woodlands					36	1.47
3. Tropical dry forests/woodlands	238	11.42				
4. Warm deserts/semi-deserts	35	1.63				
5. Mixed island systems	177	10.43	54	4.13		
Total	572	27.57	54	4.13	36	1.47

(a) Number of protected areas.
(b) Total area (million ha)

Source: Ref. (3).

The establishment of a protected area does not in itself ensure that the biota contained within that area will be saved. Good management is the first critical factor. A second factor, which will affect protected areas in much of the developing world, is the accelerating pressure for land by expanding human populations. The validity of apparently "locking up" large tracts of land will be increasingly questioned. To meet this challenge, the socio-economic benefits of protected areas and national parks will have to be maximized, particularly those benefits that accrue to people living in their vicinity. In short, more efficient use will have to be made of protected areas and people will have to be seen to benefit from them.

The future planning of protected areas is likely to become more detailed and refined, while management will be more specific and intensive. Emphasis will be on developing strategies, systems and mechanisms that involve and integrate local communities in protected area management. The oft-quoted educational, research and genetic resource value of national parks will have to return tangible benefits to society. Protected area and national park managers need to become less isolated from other resource disciplines and, where appropriate, should coordinate their planning and activities with other environmental protection efforts (e.g. mountain watersheds, anti-erosion, desertification). Close cooperation with plant and animal geneticists in the area of in situ genetic resource conservation would be mutually beneficial. Much concern can be anticipated about the integration of protected areas and national parks into overall land-use planning in the context of rural development. In future, management will need to be positive and decisive - the days of endless studies are past.

Though the first priority of a wildlife and national parks management programme must be the conservation and rational use of natural ecosystems, only if the resource base is secure can management of wild populations for enhanced production take place. Such management should take place outside national parks and reserves. The concept of the "buffer zone", managed for the benefit of the local people, is useful in this regard. Buffer zones are strips of land along the boundaries of national parks and reserves which meet the needs of the local people for fuelwood, timber, forest produce, grazing for domestic stock, hunting, and perhaps the planting of perennial crops. However, the buffer zone concept has yet to be actually applied in the region and considerably more work should be done in this area in the near future. Buffer zones could also be used for wildlife farming, provided that land tenure problems can be solved. (5)

Some innovative approaches for involving the people are being tried out in the region. In Papua New Guinea, (6) for example, some wildlife management areas are run by committees of people with traditional land rights to the areas. The committees, chosen by the people, decide on the rules for looking after the area. These rules become law only when they have the support of all and are endorsed by the government. Since the creation of this programme in 1974, the number of wildlife management areas has increased. The most significant aspect of the programme is that the government works with the people while letting them help themselves by conserving the natural resources on their lands. Thus, all operations have one central purpose - the benefit to the local community.

5.4 WILDLIFE DEVELOPMENT POTENTIAL AND CONSTRAINTS

Game meat has been used by man since prehistoric times, although with the advent of agriculture and the decrease in man's eagerness to hunt, it has gradually been replaced by domesticated animal meat. (7)
In several Asian and Pacific countries however there is a growing recognition that wildlife farming (the breeding of wild animals for meat, hide, sport, or even release in the wild) can utilize wildlife resources for the benefit of rural people. Such farming should involve carefully selected species and a good deal of organization. The choosing of wild animal species suitable for farming requires detailed knowledge of rates of reproduction, meat yield, resistance to disease, behaviour under controlled conditions, ease of rearing, quality and markets for the product, and the economics of the enterprise.

A number of wildlife farming activities are underway in the region. Crocodiles are farmed profitably in Thailand, Indonesia and Papua New Guinea. India has established a Central Crocodile Breeding and Management Training Institute. In Thailand, "true farming" (where eggs are laid in captivity), became necessary because wild populations were being wiped out by overhunting. In a crocodile farm south of Bangkok, about 6 000 crocodiles a year are produced, earning an annual profit of nearly US $1 million.

Musk deer are farmed in China, various deer species in Viet Nam, and sambar and hog deer in Thailand. The Republic of Korea, Papua New Guinea, Mongolia and Bhutan are developing deer farming programmes. Deer farming has become an important cash crop in Chinese communes and a kilo of sliced, dried antler fetches 84 _yuan_ (2 _yuan_ = US $1 approx.). In Hong Kong the same commodity costs US $100 per ounce.

Trade in monkeys has tremendous potential. Two species, the rhesus and the long-tailed macque, are important for biomedical research, with an annual demand for 50 000 to 80 000.

Sea turtles, an important source of food and trade in the region, are seriously threatened by over-exploitation; sea turtle farms would help meet the demand for eggs and meat. Some experience has already been gained in turtle hatcheries in Malaysia and India. Indonesia, with its long coastline and thousands of uninhabited islands, could assist in developing the turtle industry.

Elephants are important for the teak trade, but captive herds have a low rate of reproduction; there is scope for improved management. The ultimate goal might be to make the elephant a truly domestic animal, with selective breeding for desirable characteristics. Pheasants, wild boar, rabbits and monitor lizards also have potential for wildlife farming.

Animals which can be considered for game ranching in India, for instance, are nilgai, chital, sambar, hog-deer, pig and blackbuck. For meat production, the nilgai is the most suitable since it can weigh from 223 to 268 kg and is similar to the African eland which has been bred successfully. Sambar and spotted deer reared under semi-natural conditions breed prolifically when enclosed in forest pockets of 20 ha, with enough fodder resources. The breeding rate is very high when the predator factor is absent. In Andaman, chital released in the past have multiplied rapidly because there were no predators. They have now become a threat to the forests and cultivation. Hence the deer has become a source for extensive harvesting.

There are, however, several constraints to wildlife farming. The problem of land tenure in many countries makes it difficult for the small farmer to support an economic herd. There is always the danger that current economics, based on demand exceeding supply, will quickly reverse once wildlife farming becomes widespread. If crocodile leather becomes available at half its current price, farms may not remain economic.

There is a lack of government support for wildlife farming. While livestock departments offer a wide range of services for domestic cattle, ranging from veterinary care to marketing facilities and loans, such support is not available to the wildlife farmer. Wildlife farming should not, of course, be allowed to detract from the conservation of species in the wild, nor contribute to the depletion of wild stocks.

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(1) FAO. 1980 International Consultation on Wildlife Resources for Rural Development in Tigerpaper, Vol. VII, No. 3, July 1980. Bangkok: FAO Regional Office for Asia and the Pacific.

(2) FAO. Wildlife Resources as Food, in Tigerpaper, Ibid.

(3) IUCN. 1985 1985 United Nations List of National Parks and Protected Areas. Gland.

(4) FAO. 1985 FAO Production Yearbook 1984. Rome.

(5) Child, G.S. 1982 FAO and Protected-Area Management: Where do we go from here?. Paper presented at the World National Parks Congress, Bali, 11-22 October 1982.

(6) FAO. 1980 Country Statement: Papua New Guinea in Tigerpaper, op. cit.

(6) Naidu, M.K. 1980 Potential of Game Farming for Rural Development in Tigerpaper, op. cit.

6. PASTURE AND LIVESTOCK RESOURCES

During the last two decades, world attention has focused on the green revolution in crop production. By contrast, livestock has received little attention. Yet there are possibilities for similar improvements in animal production, particularly in the areas of animal breeding, feed utilization and disease control.

Livestock systems in Asia and the Pacific are characterized by low levels of productivity, especially among small-scale producers. Improvements in the integrated crop-livestock system, under which most cattle and buffaloes are produced, would lead to widespread improvement in rural welfare. In the richer Asian countries, rapidly-rising incomes have led to greater demand for meat and dairy products. In the long term, this will affect the overall pattern of agricultural production in the region.

In this era of concern about energy supplies, ecological balance and environmental quality, several non-food attributes of livestock also take on importance. There is renewed interest in animals as sources of draught power, fibre, and biomass for manure and fuel.

To increase livestock production, economic as well as technical constraints must be overcome. Research has thus far focused mainly on technical issues, including improved breeds, and feed and production systems. Relatively little research has been devoted to identifying the economic and social factors determining the ultimate success of the various projects, programmes and regulations that make up national livestock policies. The most striking gains in livestock productivity have been achieved with technologies imported from developed countries. However, these tend to be highly commercialized and specialized approaches which do not take into consideration the improvement of existing production systems and lead to greater dependence on imported capital goods, technical expertise and animal feed.

Traditional farming systems involving livestock can be improved, or adapted, or new systems introduced more appropriate to the economic and social environment of developing countries. This improvement rests on technological upgrading in three main areas: livestock feeding, breeding and health. To be sucessful, animal feeding systems require effective management of pastures, ranges and wastelands for ruminant production; emphasis on forage grasses and legumes as integral components of crop production; wider use of local crops as substitutes for imported animal feed; improved storage and processing, better digestibility and fuller utilization of straw, bagasse, rice bran, banana stems and other by-products.

The strategies adopted for livestock feeding will strongly influence those for breeding. The best approach would appear to be the selection and up-grading of economically-useful local stock by drawing if necessary on breeding material and genetic improvements from other countries. Emphasis should be given to breeds and species adapted to specific conditions and uses, e.g., the water buffalo for draught power, milk and meat in the humid tropics; camels, sheep and goats for arid environments. (1) Annex Table 10 shows the permanent pasture and livestock in the region in 1983.

6.1 PASTURE RESOURCES

In monsoon Asia, the climax vegetation consists of forests (with some savannas) on marshy or periodically-flooded land and steppe. Grazing land ecosystems are secondary formations, created by fire and/or over-grazing over millennia, leading to steppe-like formations even in areas of relatively high rainfall. (2) On the other hand, temperate Central Asia's climax vegetation is probably steppe, not much different from the present day vegetation.

Steppe formations occupy large areas of the middle and lower Indus Valley, in Sind and West Rajasthan; average rainfall is less than 200 mm annually, with a dry season of 10 to 11 months and a large variation in rainfall. These areas have the appearance of desert pseudo-steppes, with grass, herbs and shrubs. The soil is exposed and sometimes rocky, but more often sandy with fixed or mobile dunes.

The grazing land ecosystems of Southeast Asia are mostly formations which have been substituted for forest climax. A common feature is the predominance of Imperata cylindrica, a pioneer species leading to re-establishment of natural vegetation in abandoned cultivated areas. Strong structural and dynamic similarities exist between the main types of grazing land ecosystems found in the monsoon climates of Asia. A small number of genera, and even of species, play an important role and are common to all ecosystems.

Livestock husbandry in Southeast Asia poses less problems than in other tropical areas. With a humid climate and a forest climax, plant-based civilizations have developed, practising shifting agriculture; large areas have been converted into savannas which are under-used by livestock, especially in the Philippines and Indonesia.

Intensity in the use of grazing lands varies significantly from one country and region to another. Immense areas of undergrazed land are found in monsoon Asia, such as the 23 million ha of grass savannas in Indonesia, and the 44 million ha of Imperata savannas and secondary forests. By comparison, almost all vegetation types accessible to livestock are grazed or overgrazed in India.

Because of their great variety, it is difficult to give a precise estimate of the total area occupied by grazing land ecosystems in Asia and the Pacific. The extent of grazing land resources in South and Southeast Asia is much larger than indicated by land-use classifications. A very approximate estimate of the extent of tropical grazing land resources can be made on the basis of the land-use figures published by FAO. (3)

Annex Table 3 shows that the total land theoretically available for grazing, and indeed used to a great extent for that purpose (i.e. permanent pasture as well as arable land), is as much as 808 million ha, whereas permanent grasslands and pastures account for only 45 million ha. Even this figure may be under-estimated, as, in some countries, forests are also used extensively for grazing. In 1976-77, nearly 2.2 million head of cattle grazed in the forests of Uttar Pradesh, India. Forest trees are heavily lopped for fodder in the Himalayan zone. In Nepal, leaves make up about 40% of the annual feed for a buffalo and about 25% for a cow.

There are extensive grasslands in China. Out of a total of about 319 million ha, some 225 million are considered usable, mostly located in Inner Mongolia, Xingjiang, Gansu, Tibet and Qinghai. In addition, there are 66 million ha of grass-covered mountains and 54 million ha of barren mountains and fields suitable for afforestation. (4) These grasslands

exist in a deteriorated state, with considerably reduced yields since the 1950s. Over the last few years, the Government has taken steps to rehabilitate these grasslands.

The mixed-farming system of agriculture and animal husbandry practised in the hills depends, to a far greater extent than is realized, on the ecosystem as a whole. Forest land is just as much an integral part of the farming system as arable land and livestock. Data from West-central Nepal indicate that a family of five to six on an average farm holding of 1.25 ha requires, with present agricultural and forestry management practices, 3.5 ha of land for fodder, 0.3 to 0.6 ha for fuel, and 0.4 ha for timber. The data indicate that the provision of livestock fodder is a greater problem than the production of fuelwood. (5)

The mapping of grazing land ecosystems, together with their nature, structure, potential and eventual uses, is urgently required in order to obtain better estimates of their extent. Not only must the type of vegetative cover be taken into account, but also the way in which it is used. This cannot be obtained until a detailed inventory of natural resources is available.

6.1.1 Fodder crops in agroforestry systems

In agroforestry systems, tree and fodder crops are grown in such a way as to make use of the different layers of soil. The combination not only prevents erosion and loss of nutrients through leaching, but makes more efficient use of the land's potential. If properly managed, agroforestry should be suitable even for highly-productive lands under settled multi-cropping agriculture, and should be capable of improving the productivity of tropical soils in particular. The aims of agroforestry are twofold: to conserve and improve the site, and to maximize the combined production of forest and agricultural crops and animal husbandry. (6).

In most parts of the Asia and Pacific Region, farmers practise a combined system of animal husbandry and agriculture. The integrated use of forests, pastures and crops is important for environmentally-sound management, especially to protect watersheds and increase productivity of the fragile lands to meet the needs of local populations. Effective community involvement is crucial for implementing integrated land-use systems based on agroforestry.

Social forestry is a recent development, based on the "multipurpose tree use" concept. Tree species are planted which produce fuel, fodder, fruits and other minor forest produce, with grass and legumes in the interspace, which can be cut or, when the plantations are established, used for controlled grazing.

Work undertaken by FAO in an integrated watershed and forest land use project in Chiang Mai, Thailand, shows the major role of legumes in agroforestry (7). Tribes of 12 ethnic groups (50 000 households) occupy the highlands: 60% practise settled bush-fallow cultivation and the remaining 40% cultivate opium and practise shifting cultivation and fell virgin forests in a five-year cycle. This leaves the earlier holdings impoverished of soil nutrients, fit only for the growth of Imperata cylindrica, which, when dry, is a fire hazard.

Legumes can be incorporated in crop rotation as cover for preserving moisture, checking soil erosiong, restoring soil fertility and providing fodder. Local varieties of Leucaena are raised in the Kanchanburi province and the leaves sold for human and livestock consumption. As a source of fertilizer, feed and fuel, it excels all

legumes. Experiments have shown that L. leucocephala yields as much as 18 tonnes of leaf meal/ha/year. Two legumes, Lablab purpureus and Stylosantes guianensis have shown promising results in Pongkhrai (elevation 1 008 m). In ploughed fields, the growth is so vigorous that, planted in May, a Lablab local variety covered the entire area by June, and smothered Imperata growth completely.

To prevent overgrazing of pasture land, it is essential to erect fences, which can be a major expense. However, many shrubs, (Leucaena, pigeon pea, cactus and euphorbia), can be used as living fences.

6.2 LIVESTOCK RESOURCES (1, 8, 9)

In Asia and the Pacific there is a marked imbalance between animal resources and available grazing lands. The region has about a third of the world's livestock population, but contains less than one fifth of the grazing lands (Annex Table 3). Livestock is an integral part of farming systems in the region. Within extensive pastoral systems and small-scale farming, livestock is of inestimable value in utilizing land or feed materials not used directly by man.

Table 6.1 shows the livestock population of the region in 1983. 96% of the buffaloes in the world are raised in the region, as well as 46% of both goats and pigs. Cattle are distributed fairly evenly across the region, but not the other animals. Most of the pigs are raised in the Far East, China and the Pacific Islands, while most of the buffaloes occur in South and Southeast regions.

Table 6.1 Livestock population in the region (1983)

Species	Asia and Pacific	World	% of world population
	--------(thousands)---------		
Cattle	332 878	1 259 545	26.4
Buffaloes	120 536	125 565	96.0
Sheep	194 685	1 131 459	17.2
Goats	214 867	467 523	46.0
Pigs	356 733	773 679	46.1
Chickens	662 358	6 705 934	9.9
Ducks	57 570	144 659	39.8

Source: Ref. (3).

The livestock industry in the region is based on two different systems: the pastoral system and the sedenterized agricultural system. In a few countries (e.g. Mongolia and Pakistan), the majority of livestock is raised in the pastoral zones. In others, (e.g. Republic of Korea, Democratic People's Republic of Korea, Malaysia, Lao and the Pacific Islands), almost all the livestock are integrated into the agricultural system. In still others (e.g. India and China), both systems exist. In China, about three quarters of the livestock are raised in the agricultural system, including 96% of swine, and 92% of donkeys and mules. (11)

Draught animals are the most important single grouping among cattle and buffalo populations in Asia and the Pacific. For most of the region, there is one draught animal per ha of land, but much of Southeast Asia has an acute shortage of work animals. Animals are a more important source of

power for agricultural production than tractors, providing 23% against 9% for tractors. Draught animals are also used for transport. It is estimated that 20% of the world's population is dependent upon animals for transport, as a source of power for processing crops, and for irrigation. In China, about 53% of all large livestock (56% of which are cattle) are used as draught animals to cultivate an estimated 58% of agricultural land, the rest being cultivated by tractors. (11)

Where the ground is too hard for hand cultivation before the rains, or where double or triple cropping is practised, the timing of land preparation and planting is critical. Without draught animals, the chances of a successful crop under these conditions are poor. Draught animals may be used only 30 to 50 days a year, but without them the farming system would collapse. Similar peaks in power requirements may occur at harvest time, when animals are used to gather and thresh grain.

The integration of draught animals into agricultural systems is particularly important in areas where land is a limiting factor. The provision of feed in these areas is a serious problem because of the scarcity of forage. Lack of adequate feed reduces the work force of the animals and increases their susceptibility to diseases.

Though a number of countries also encourage the use of tractors, particularly hand tractors, their purchase and operational costs pose problems. Thus, draught animals continue to be important for many low-income farmers.

The faeces of livestock improve soil fertility. Dried ruminant faeces are also an important as fuel in parts of the region. In a number of countries of Southeast Asia, livestock excreta are used as feed and fertilizer for fishponds, often integrated with duck production. Using this system, commercial yields of 10 tonnes fish/ha/year have been recorded. The carcasses of livestock provide a number of products other than meat.

6.2.1 Livestock productivity

Livestock industries in developing countries received considerable attention and support during the 1980s in terms of research, financial assistance, private investment and government programmes. In those countries where economic transformation has been rapid and sustained, the contribution of livestock to total agricultural production has increased substantially. In the Republic of Korea, the contribution of livestock rose from 14.6% in 1975 to 25.3% in 1983 (a 73% increase). In Indonesia and Thailand, the share of livestock actually decreased (Table 6.2).

These patterns indicate that growth in demand for livestock products is heavily dependent on economic growth. The per caput consumption of livestock products in most countries of the region does not meet minimum dietary requirements.

Recent figures (Table 6.2) indicate that growth of the two major species, cattle and water buffalo, was relatively low compared to swine, which showed moderate to strong growth. Cattle poplations actually declined in Central Asia, and sheep populations declined in the Pacific Islands.

Table 6.2 Gross output of livestock and livestock products as percentage of total agricultural production in selected countries(*)

Country	1975	1983	Change
	--------	% --------	
India	17.2	19.7	+ 15
Indonesia	8.2	7.9	- 4
Korea (Rep.)	14.6	25.3	+ 73
Pakistan	26.4	27.6	+ 5
Thailand	15.3	14.9	- 3

(*) In constant 1971 prices (local currency)

Source: Ref. (12).

Table 6.3 Average annual change in some animal populations in Asia and the Pacific between 1974 and 1983

Region	Cattle	Sheep	Goats	Swine	Buffaloes
	--------	--------	% --------	--------	
South and Southeast Asia	0.94	1.49	2.13	4.09	1.14
Central Asia	-0.25	1.28	1.40	1.38	0.38
Oceanic Asia	-0.18	-2.80	0.90	2.19	0

The outstanding feature of cattle and water buffalo production in the region is the low meat offtake per unit. Asia has 37% of the world's combined population of cattle and water buffalo, but produces only about 10% of the world's cattle and buffalo meat. The same general pattern applies to sheep and goats. Although the figures for the Far East are quite high by developing-country standards, 46% of the world's small ruminant population held in Asia produces only 29% of the total world supply of sheep and goat meat. Small ruminants are kept mainly for their milk.

For non-ruminants, an important distinction needs to be made between the modern and traditional sectors. The modern sector has productivity levels almost comparable to developed country standards, whereas traditional village subsistence production achieves levels far below those of the modern sector.

Apart from India, the region is characterized by a group that has little net trade: a traditional exporter (Thailand), an occasional exporter (Indonesia), and rapidly-growing import markets (high and low-income East Asia).

The most rapid expansion has occurred in the pig and poultry sectors because of technology transfers from temperate regions and a gradual expansion of international trade in feedstuffs. This encouraged rapid growth in these sectors, using predominantly industrialized forms of production clustered around major urban markets, often points of entry for imported feedstuffs. These developments caused a gradual reduction in the importance of land resources as a limiting factor governing output of pork, poultry and eggs. Supplies of these products have become more dependent upon the availability of foreign exchange to finance imports of feedstufffs, and the growth of domestic markets to absorb the increased output.

The ruminant animal industries in the region have experienced no comparable increases in productivity or in easily-accessible feed supplies and so continues to depend on domestic resources. This sector retains its location-specific character because large quantities of low-cost roughage is needed that can only be supplied economically from local resources. Thailand and the Philippines, for example, with relatively abundant roughage supplies, have much lower beef prices.

The labour and capital-intensive type of livestock farming frequently seen in Europe and North America is well adapted to economies where capital is available, surplus grain exists and labour prices are high. These conditions seldom prevail in developing countries where livestock husbandry is usually geared to a low-input system which maximizes the use of land and waste materials unsuitable for use by humans. It is this ability of livestock, particularly ruminants, to utilize such materials and be an integral part of the farming system, that constitutes a major, if largely hidden, asset in the agriculture of the region.

6.2.2 Livestock development strategies

There is no easy solution to increasing animal products. Technology has neglected the enormous variability of farm resources and animal practices in the region. There is inadequate understanding of the animal management techniques practised by the farmers and the rationale behind these practices. Unfortunately, the need for change within the complex traditional crop/livestock farming system does not suit the large-scale project approach of governments and donors.

Strategies for improving productivity differ within the region. Where livestock production is based on pastoralist systems, it is necessary to ensure that thresholds of resource tolerance are not exceeded by human or animal pressures, especially during drought years. On arable lands, the most successful approaches are likely to be those based on integrated crop/livestock farming systems, including efficient utilization of crop residues and agro-industrial by-products for animal feeding. Where land is not a limiting factor, the greatest need is for systems of grazing management that fit into traditional patterns of farming. Far too often, livestock is seen as a single-dimensional commodity. Insufficient allowance is made for the multiple purposes animals often serve in a village setting. Viable solutions are not simply a matter of technology transfer because both technical and social problems have to be overcome.

The extent to which tree crops are used in conjunction with food crops and livestock is an interesting feature of integrated agriculture on small farms. Leguminous trees and bushes are cut extensively to feed livestock, the best known being *Leucaena leucocephala*. Another form of integration involves grazing livestock under tree crops. Various pasture legumes are used as cover crops under rubber in Malaysia and Sri Lanka

where, although the shade prevents good forage yields, it permits the growth of seed material. Forages are also grown successfully under coconuts in a number of countries of Southeast Asia and the South Pacific. However, once a dense canopy forms, insufficient light penetrates to permit a good stand of forage. From the development standpoint, the greater use of short-season forage legumes and tree crops such as Leucaena and Glyricidia offer good prospects. These leguminous trees have two other benefits: they add nitrogen to the soil, thus influencing crop yields, and they provide some fuelwood as a by-product.

The constraint imposed by nutrient supply within the traditional system must also be recognized. Strategies should be based on increasing the volume of nutrients moving through the system. Grazing animals, in particular, act as collectors of low-nutrient material, which they then supply to humans in a more concentrated form for use as fuel or fertilizer (manure) or as food (meat and milk). The higher the population density and the more intensive the agriculture, the more important this collection function becomes.

Viewed against the feed resource base, the recent proliferation of cross-breeding programmes for milk and meat production in the region gives cause for concern, because they are often accompanied by implicit acceptance of high levels of concentrate feeding. A breeding programme should have as its objective the production of animals which use feed resources in the most efficient way.

The Republic of Korea is developing its dairy sector to meet the anticipated demand for dairy products caused by a rapidly developing economy. There is a well-developed transport system to get the raw product to the processing centres and the final product to retail outlets, and favourable environmental conditions for imported dairy cattle. Milk production in 1984 totalled only 5 118 kg of fresh milk, but average per caput consumption increased from 0.05 kg in 1961 to 8.8 kg in 1978 and 12.2 kg in 1983. Much of the growth was taken up by increased imports of concentrate feeds. This has meant that the major input cost (feed) was at international market prices, which has made milk somewhat of a luxury, based on income levels in the country. Milk consumption by the lowest income group is 31.5% that of the average level, whereas the highest income group consumed 69.8% more than average.

Current development strategy in the Republic of Korea is to relocate dairying to marginal areas of hilly land suitable for pasture production. Imported stock is distributed to farmers in rural, hilly areas, and pasture development costs are subsidized. On larger farms, 30% of the cost is government subsidized, whereas on smaller farms, 68% is subsidized. Another 14% is met through government loans.

India's livestock development strategy is based on smallholder dairy development. Initial emphasis was on transmitting to the rural producer the high urban demand for milk in the four major cities of India. This was done through cooperatives, offering the dairy producers an assured and attractive yearly price for their milk, and organizing its processing and marketing. These measures enabled producers to raise their incomes by 50% or more. The farm level inputs in these early years included little more than an effective harnessing of the low-cost inputs of labour, grazing on non-arable land, crop residues and waste by-products.

The second phase of the smallholder dairy development programme in India, which ended in December 1985, involved an outlay of over US $600 million, and aimed at assisting some 10 million rural milk producers to build a viable, self-sustaining dairy industry and to facilitate the

rearing of a national milch herd of some 15 million crossbred cows and improved buffaloes. Critical to the success of this ambitious project was the development of a forage and feed resource base for the maintenance of this national herd. It called for the selection and breeding of more productive forages (in particular leguminous forages such as berseem and lucerne) that the smallholder would be encouraged to incorporate in his crop rotations, and new technques for higher forage production from poorer soils (for example, the planting of Leucaena patches in communal grazing areas, which help to integrate animal production with nitrogen fixation and soil building).

As regards beef production, there are few success stories. The consensus among researchers is that long-term programmes are required to improve the productivity of ruminants and non-ruminants on the mixed farms predominating in the region. In many cases, the focus should turn away from large animals toward small ruminants.

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(1) FAO. The State of Food and Agriculture 1982. Rome. 1983

(2) Unesco/UNEP/FAO. Tropical Grazing Land Ecosystems. A State-of-Knowledge Report. Natural Resources Research XVI. Paris: Unesco. 1979

(3) FAO. FAO Production Yearbook 1984. Rome. 1985

(4) Wang Huaijong, et. al. Natural Resources of China's Agricultural and Environmental Protection. Mimeo. 1984

(5) Wyatt-Smith, J. The Agricultural System in the Hills of Nepal: the Ratio of Agricultural to Forest Land and the Problems of Animal Fodder. Kathmandu: Agricultural Projects Service Centre. 1982

(6) FAO/SIDA. India and Sri Lanka: Agroforestry. FAO/SIDA Forestry for Local Community Development Programme. Rome: FAO. 1981

(7) FAO. Mae Sa Integrated Watershed and Forest Land Use Project, Chiang Mai, Thailand. FAO/FO/THA/76/001. Rome. 1979

(8) Mahadevan, P. Pastures and Animal Production in International Symposium on Nutritional Limits to Animal Production from Pastures, 24-28 August 1981, St. Lucia, Queensland, Australia. Farnham Royal, UK: CAB. 1982

(9) De Boer, A.J. Livestock Development: the Asian Experience in Livestock in Asia: Issues and Policies. Ottawa: IDRC. 1982

(10) FAO. Animal Energy in Agricultture in Africa and Asia. FAO Animal Production and Health Paper No. 42. Rome. 1984

(11) Piliu, Zh. Livestock Breeds of China. FAO Animal Production and Health Paper No. 46. Rome. 1984

(12) FAO. Statistics on Economic Accounts for Agriculture 1975-1985. 1985

7. FISHERY RESOURCES

Asian waters produce an annual fish catch of over 25 million tonnes. This represents nearly 40% of the world's total marine fish catch, and 80% of inland fish and aquaculture production. Yields from marine and inland capture fisheries could be increased some 30 to 65% by careful management and the use of under-exploited stocks, as only about 10% of land and water areas suitable for aquaculture are currently being utilized. Annex Table 11 shows fish catches in some Asian countries.

Fish is a major source of protein in a number of countries of the Asia and Pacific region. In 13 countries, it contribute more than 40% of the total animal protein supply, and in a further 6 countries, between 20 and 40%. In some countries, fish is also an important source of foreign exchange, vital to the existence of the economy. In the Maldives, fish products account for nearly 97% of total exports; and in the Solomon Islands, for over 28%. (1) In Thailand, Papua New Guinea, India and Bangladesh, fish is an important export; any change in supply and demand would have considerable repercussions on the economies of these countries. There is a substantial two-way trade in Fiji, Hong Kong and Singapore.

The new legal regime of the seas has adversely affected the fishing interests of some nations. Thailand has lost 768 000 sq km of fishing grounds although this is somewhat offset by more joint fishing ventures with neighbouring countries, e.g., Thailand with Burma, Indonesia with Bangladesh. The new regime will give several countries access to and control over an expanded area, but they will need increased investment, development and marketing assistance.

7.1 INLAND FISHERY RESOURCES (2, 3)

Fresh and brackish water bodies in the region have long supported subsistence, artisanal and commercial fisheries. Increasing pressure is being placed on fish stocks, by intensified fishing, modifications in the environment through deforestation and agriculture (leading to increased erosion), pollution, and modification of water courses due to damming, irrigation diversion, drainage, etc.

Some inland fisheries are beset by environmental problems. In China, production fell from 600 000 tonnes in the 1950s to about 300 000 tonnes in the early 1970s. The reclamation of marshlands for grain production, regulation of rivers for flood control, chemical pollution and the over-harvesting of wild fish seed for use in aquaculture, are all, to varying degrees, responsible for this decline. Since then, China has instituted various controls and regulations which collectively resulted in a three-fold increase in production by 1975 (1.1 million tonnes). This increased to 2.3 million tonnes by 1984 (an increase of 109%).

The experience of industrialized countries, with heavily-polluted lakes and rivers, has shown that productivity can be restored if appropriate action is taken. Rural populations benefit mostly from inland fisheries in the region, and efforts should be made to protect these fisheries from the encroachment of other interests. Recent statistical and analytical studies of riverine fisheries have shown them to be far

more important economically than previously suspected. Riverine fisheries with a well-developed floodplain regime have been shown to be the most productive of natural fish resources. Flood control and other river modifications have been particularly damaging to many of these traditional fisheries.

Inland fisheries depend not only on the main rivers, but also on associated floodplains, reservoirs, lakes and swamps. Because such systems are dispersed and the yield of individual streams is frequently small, it is difficult to obtain accurate statistics. In general, only catches from the more important fisheries of lower reaches, or of the larger floodplains or lakes are reported. In some river basins, extensive fish culture practices, such as rice/fish culture, fish parks and fish holes, are integrated with the general capture fishery. Nevertheless, fish catches from inland waters of the region can be generally estimated at around 3 million tonnes.

Rapid population growth in the region and the consequent expansion of agriculture, and domestic and industrial activities for which water is essential, are together responsible for shifting priorities from inland fisheries development to other uses. Decision makers seldom take into consideration the effects of these multiple activities on fishery resources.

A survey of the inland streams in Sri Lanka shows that a number of endemic fish are threatened with extinction and others are depleted due to deforestation, urbanization, gem mining, pesticides, water diversion, exploitation, and the introduction of exotic species. The rapid development of river basins in the last three decades has put pressure on land and water resources, and, consequently, on fish and other economic aquatic stocks. In India, Pakistan, and Bangladesh, catches of riverine fish, (e.g. Shad and Hilsa), have diminished considerably owing to over-exploitation.

Poor land use (e.g. deforestation and overgrazing) has caused siltation of numerous rivers in the region, such as the Agno in Northern Luzon (Philippines), rivers flowing from the Himalayas, and rivers in Malaysia. Pollution of the Chao Praya River in Thailand, due to the absence of effective laws and measures for control of wastes discharged into the river from Bangkok, has given fish a heavy-metal content in excess of the upper allowable limit, and such fish cannot be marketed in Western countries. Mine-tailing discharges have caused serious problems in several of the region's water bodies. Copper mining in the Philippines, and tin mining in Malaysia, are especially serious. Malaysia has legislation, but poor enforcement. Frequent tropical storms cause overflowing of tailing ponds and result in fish kills and deterioration of water quality.

Of 3 900 industrial firms in the Philippines, 469 have no waste treatment plants. One of the most polluted rivers is the Pasig, which traverses Manila. Fishing in this river is only possible when the waters from the Laguna Bay flush out the river into the sea during typhoons. Industrial pollution of the rivers Palico and Bagbag resulted in an end to fishing for 300 families.

7.1.1 Reservoir fisheries (4, 5)

There are almost no free-flowing rivers left in the region. Most freshwater fisheries have been converted from riverine to lacustrine, mainly because of the long history of rice cultivation in Asia, dating back to the 4th century BC. Many reservoirs built in areas with a

seasonal supply of water are over 1000 years old. However, in recent years, fish production in rice fields has declined because of increasing use of pesticides and double-cropping systems. In the last 50 years, multi-purpose reservoirs of much larger size have been constructed for power generation and irrigation.

The development of the Mekong basin is one such example. Twelve dams were built on the Mekong and its tributaries for hydropower production, irrigation, transport, flood control and urban water supply. Uncontrolled settlements around the reservoir have led to overfishing. Changes in the hydrological regime and development of new agricultural systems, intensive cropping, and the use of pesticides and fertilizers, have all adversely affected fisheries in the basin.

The number of reservoirs is steadily growing. Rivers are being dammed, and the water level of natural lakes raised. In 1976, the reservoir area of Southeast Asia was estimated at 30 000 sq km; this is expected to increase to 150 000 sq km before the turn of the century. There are over 280 large reservoirs in China. Table 7.1 gives some types of standing water in Southeast Asia.

Table 7.1 Approximate areas of some types of standing water in Southeast Asia

Country	Reservoirs		Rice fields	Natural lakes
	Present	Year 2000	(1975-76)	marshes & flooded areas
	----------million ha----------			
Bangladesh	0.16	0.80	9.70	0.30
Burma	0.20	1.50	5.10	0.60
India	2.00	5.00	38.60	0.70
Indonesia	0.13	0.50	8.50	9.95
Kampuchea	0.08	2.00	0.68	0.50
Lao	0.05	5.00	0.66	0.50
Malaysia				
Malaya	0.02	0.15	1.70	0.01
Sabah	NA	NA	0.10	1.00
Sarawak	NA	NA	0.14	3.22
Nepal	0.02	0.10	1.20	0.01
Philippines	0.03	0.50	3.66	0.40
Singapore	0.002	0.003	Nil	Nil
Sri Lanka	0.13	0.25	0.63	0.82
Thailand	0.30	3.00	7.80	0.60
Viet Nam	0.20	1.50	6.00	0.50

Source: Ref. No. (4).

NA = no data available.

During the filling period of reservoirs, the water leaches nutrients, submerged plant debris and other organic matter from newly inundated soils, so the impounded water is highly fertile, encouraging the growth of bacteria, phytoplankton, zooplankton and benthos. These organisms serve either directly or indirectly as food for fish which, consequently, become more abundant, as do the predacious species which feed on small fish.

This high production pattern is usually not sustained. After the initial years, it often declines rapidly to a lower level, which may be maintained or may gradually rise to half the magnitude of the first phase. Eventually, fish yield approximates or slightly exceeds that of a natural lake of similar size and shaps. This phenomenon is typical of deep reservoirs with steep bottom slopes. It is less of a problem in large, shallow reservoirs, since fish production there usually fluctuates at the initial high production level and may even increase.

The productive capacity differs for each reservoir and may even fluctuate from year to year in the same reservoir, depending on its water supply and the activities of users.

Fish production in reservoirs in Thailand has increased to much higher levels than in rivers. Production in the Ubolratana Reservoir increased from 474 tonnes in the first year of impoundment, to 2 100 tonnes in the fourth year, the maximum yield of 2 480 tonnes occurring in the ninth year. In India, fish yield in the Rihand Reservoir reached its peak in the fourth year of impoundment. Annual fish landing from Gandhi Sagar Reservoir (area 660 sq km, maximum depth 50 m) reached its first peak in the fourth year, but maximum yield of 697 tonnes was obtained only in the 13th year, after closure of the dam. The increase in fish catch in latter years was primarily due to the stocking programme, application of fishing regulations and increased fishing.

7.1.2 Aquaculture (6, 7, 8)

In 1983, about 77% of the world's aquaculture products came from the Asia and Pacific Region. Between 1975 and 1980, ths region showed the highest annual increase in the world (7.6%). In 1980, 60% of production was finfish, 18% molluscs, 20% seaweed and 2% crustaceans.

Aquaculture has a long history in the region. Ovsr the past decade it has been given high priority in national programmes, to compensate for the increased operational costs of capture fishing, declining catches from national waters, and, for countries such as Thailand, reduced access to foreign waters as a result of sxtended fisheries jurisdictions.

Frsshwatsr aquaculture is a major part of China's fishing industry. About 74% of all output is finfish (mostly freshwater), while the rest is mollusc and seaweed from coastal aquaculture. Production of finfish between 1975 and 1980 showed the greatest annual decline in Thailand (13.22%) and the greatest annual increase in Nepal (51.57%), followed by the Republic of Korea (41.03%). The highest annual increase in mollusc production for the same period was in the Republic of Korea (26.69%), followed by Hong Kong (18.13%) and Malaysia (17.79%). The highest annual increase in crustaceans production was in India (33.6%). (12) Traditional aquaculture practices, governed by local conditions, are giving way to more intensive farming practices involving the rearing of dense populations.

Little information exists about the effects on local fauna and flora of introduced non-indigenous species. This is because of the difficulties in collecting reliable long-term data, and in separating the impacts of diverse causss, such as overfishing of local species, man-induced changes in habitat, competition or predation by introduced species, etc. In a few cases, there is strong evidence of a genetic erosion of local species (e.g. in the Mekong Delta and the Himalayan region). Wild seed resources are also being increasingly depleted in

several Asian countries because of their extensive use in fish farms. Most countries use seed collected from the wild, with the result that indigenous species of carp and milkfish are in danger of depletion.

However, aquaculture has an enormous potential to save endangered species by induced breeding and re-stocking depleted habitats. A Regional Workshop on Aquaculture Planning in Asia (1975), and the World Conference on Aquaculture (Kyoto, 1976), both sponsored by FAO, provided a solid basis for planned development of aquaculture. Current efforts to retock depleted habitats include such species as the giant Mekong catfish (Pangasianodon gigas), mahaseer (Tor tor), asla (Oreinus richardsoni) and the giant clam species (Tridacnid spp.).

By far the greatest threat to the survival of indigenous species probably comes from the impact of man's activities, such as dam construction, industrial pollution, watershed manipulation and degradation of uplands resulting in increased sedimentation in rivers. For example, in China, production from wild fisheries has been decreasing for the past decade, but at the same time production of aquaculture has been rising. Chinese fisheries depend increasingly on artificial hatcheries.

Greater movement of fish has also caused a rise in diseases, through the transfer of pathogens among and within regions and countries. Fish diseases originating from imported fish seed occur frequently in the region. Quarantine and fish-health services are not yet available in most countries. A major outbreak of disease a few years ago in Thailand, Malaysia, Burma and Lao is still spreading and has resulted in the depletion of the snakehead (Ophicephalus spp.), the cultured freshwater catfish, and many other local species.

In 1984, the European Inland Fisheries Advisory Commission (EIFAC), in conjunction with FAO and the International Council for the Exploration of the Sea (ICES), developed an International Code of Practice for the introduction of exotic fish around the world. The Code established guidelines aimed at reducing the spread of disease and safeguarding the genetic diversity of indigenous fish communities. (13)

7.2 MARINE FISHERY RESOURCES (8, 9)

Marine fisheries are very important in the Asia and Pacific region. Between the Arabian Sea and the Central Pacific islands, some 9 million tonnes of fish are caught, almost all by using small, locally-based fishing vessels. The shallow waters of the west coast of India and the South China Sea are among the most productive in the world, containing large numbers of relatively short-life species, with a high turnover rate. The high concentrations of a few species, which have made the North Pacific so attractive to long-range fishing fleets, are absent in the region and only some tuna fleets operate.

Despite the size of the region, there is a similarity in resources. Five main communities can be distinguished: bottom-living fish of shallow water, the deep water community (in depths beyond 50 m), coral reefs, the pelagic community of coastal waters, and the offshore deep-water pelagic community.

The shallow-water community has a variety of species, ranging from large predators (sharks, rays, groupers and snappers), to small detritus feeders, such as slipmouths. Penaeid prawns are of great economic importance, sometimes accounting for most of the value of the catch, even though they seldom make up more than 10% of the weight. Other invertebrates, such as squid, cuttlefish and crabs, are also important. This

community supports some of the most important fisheries in the region, including many of the small-scale artisanal fisheries, as well as major industrial-scale ones, such as the trawl fishery of Thailand. The shallow-water community and tuna fisheries account for the main fishery operations outside local waters. Activities have been reduced now that most countries have extended their jurisdiction, in accordance with the new Law of the Sea. Thai trawlers have worked in most parts of Southeast Asia from Bangladesh and Burma to Viet Nam and the east coast of Malaysia.

It is difficult to estimate the state of stocks because of the large number of species involved. Surveys in the Gulf of Thailand show a decline in abundance following the development of the trawl fishery, and these stocks are certainly fully exploited. Sharks and rays have been reduced to only a fraction of their original levels. In contrast, squids have increased, due perhaps to the reduced numbers of predatory fish. Also fully exploited are most of the resources along the more densely inhabited coastlines, where large numbers of fishermen exert heavy pressure on the stocks, even when using simple gear.

For many species, including the penaeid shrimp, the immediate coastal zone (lagoons, estuaries, mangrove swamps), provides nursery areas. Destruction or change in these areas (e.g. by development, construction of fish ponds or use of mangroves for fuelwood), can adversely influence the long-term productivity of these resources.

While some species are found at no more than a few metres depth, others occur in much deeper waters. Catch rates and economic returns decrease with increasing depth and distance from shore. As a result, the deeper waters are lightly fished. The penaeid shrimp, which is the most valuable single group of species, is seldom found in depths of more than 50 metres. In the South China Sea, and the Central Java Sea, biological potential is considerable due to the moderately deep shelf (extending from 50 to 200 m). However, economic returns are slight and, for the present, the prospects for large catches are small.

Coral reefs are among the best known and most productive aquatic ecosystems of the world. They occur throughout the region, especially where there are clear oceanic waters. In the small islands of the Pacific and Indian Oceans, as well as in much of Indonesia and the Philippines, they are the main resource. The range of species is immense, and the spectacular colours of some of the smaller species have made them favoured as aquarium fish, export of which is becoming economically significant in some countries.

Food for local consumption is, however, the most important use of fish resources. Large, predatory species such as groupers, caught mostly by handlines, are highly prized, but are sensitive to heavy fishing. Greater harvests are taken from species lower down the food chain (e.g., parrot fish). These are fished in a variety of ways but the practice of using dynamite, or, as in the Philippines, muro-ami, by which fish are driven into a net by beating on the coral, can cause lasting damage to reefs. Reef stocks are fully exploited, with only minor opportunities for increased production, but there appears to be opportunities for increased production from some of the small pelagic species (e.g. Sardinella spp., Rastrelliger spp., anchovies). These are abundant off the west coast of India, due to the strong seasonal upwelling. India's yearly catches of oil sardines have sometimes been over a quarter of a million tonnes. Some of the larger species, such as Decapterus, found in offshore waters, are relatively lightly exploited. The total potential of these types of fish could be 50% above the present catch of some 2 to 3 million tonnes.

Open ocean resources in the region are similar to those in other parts of the world. Most important commercially are the tunas, especially the larger warm-water species (yellowfin and bigeye) and skipjack. The other large species (albacore and bluefin) prefer cooler waters and are therefore important only on the fringes of the region, although the major spawning grounds of the southern bluefin tuna are in the tropical Indian Ocean, northwest of Australia.

The west central Pacific is the most important region of the world for tuna, accounting for a third of the total catch of some 2.5 million tonnes. Other large pelagic fish (billfish and sharks) are caught by long-liners fishing for tuna. In addition, a number of other species of commercial value (e.g. dolphin, Coryphaena hippurus) are widespread in oceanic waters, but are not taken in significant quantities. There are also a number of smaller species of tuna (T. Tonggol, Auxis spp., Euthynnus spp.) which, while not in the international tuna trade, can, and in some areas do, support local fisheries. Judging by the amount of these species consumed by larger tuna and billfish, their total production potential could be very high, possibly several million tonnes in the Pacific as a whole.

Until recently, the major tuna fishing was carried out by long-distance vessels: long-liners from Japan and Korea, bait boats from Japan, and, in the last few years, purse-seiners from the United States and Japan. The Maldives have an important export trade in dried skipjack and small yellowfin. The Philippines and other countries are now developing their own tuna fisheries, both for export and domestic consumption. Fish aggregation devices (FADs) are often used, which sometimes capture small yellowfin.

7.3 SOME RESOURCE MANAGEMENT PROBLEMS (10, 11)

Conservation of fish stocks (i.e. measures to protect them from depletion by excessive fishing), does not seem to be given much importance in the region. Few, if any, stocks have collapsed in the same way as the Peruvian anchovy or the North Sea herring. However, changes in species composition and community structure (e.g. in the Gulf of Thailand, presumably as a result of heavy fishing), shows that more attention should be paid to this issue.

The conflict between different groups of fishermen, both within and between countries, is a growing problem, involving both small-scale fishermen and those using large trawlers and other industrial-type fishing vessels. These latter are essential to catch the under-exploited offshore stocks, but tend to concentrate near shore where catch rates are better. Concern is growing over the large numbers of small fish being caught by trawlers using meshed nets, including yellowfin by the use of FADs. The increased use of these devices could cause unacceptable losses of these smaller species. Several countries have banned trawling at various distances from the coast, and Indonesia has banned all trawling.

The productivity of some coral reefs have been reduced by heavy freshwater runoff and siltation, following the cutting of inland forests. Pollution from silt, industrial effluents, mining, especially dredging for tin in coastal waters, and oil spills are damaging marine fisheries and coastal ecosystems. The straits of Malacca are considered one of the areas most contaminated by oil, which has also damaged hundreds of hectares of mangroves on the islands of the Rian archipelago, following the grounding of a Japanese tanker in 1975.

The destruction of mangrove forests to reclaim land for industrial or agricultural uses is proceeding at an unprecedented rate in Southeast Asia. For example, in Selangor (Malaysia), more than 50% of the total mangrove area has been reclaimed for housing, godowwns and industrial estates. In Singapore, the main industrial estate of Jurong stands on reclaimed mangrove land. Agro-industrial wastes discharged into waters of the region are also causing long-term damage to mangroves. Palm oil effluents discharged into a mangrove estuary in Malaysia (Sungei Poloh) completely destroyed all pelagic fauna. Some 2 km downstream, only three species of fish and prawns were found in abundance. The mangrove trees in the vicinity appear normal, but the fauna have been depleted. Mangrove plants are very susceptible to herbicides and pesticides. Military operations during the Viet Nam war destroyed over 100 000 ha of mangrove forests, leading to increased soil erosion.

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(1) FAO. 1981 The Economic and Social Effects of the Fishing Industry: a Comparative Study by H. Josupeit. FAO Fisheries Circular 314 (Rev. 1). Rome: FAO.

(2) FAO. 1983 Review of the State of World Fishery Resources: Marine and Inland Waters. FAO Fisheries Circular 710 (Rev. 3). Rome.

(3) FAO/IPFC. 1983 Summary Report and Selected Papers Presented at the Workshop on Inland Fisheries for Planners, Manila, 2-6 August, 1982. FAO Fisheries Report 288. Rome: FAO.

(4) Fernando, C.H. 1980 The Fishery Potential of Man-made Lakes in Southeast Asia and Some Strategies for its Optimization, in Biotrop. Aniv. Publ., 1980.

(5) FAO. 1980 Management of Asian Reservoir Fisheries. FAO Fisheries Technical Paper No. 207, Rome.

(6) FAO/NORAD. 1982 Asia for Aquaculture Development in the Third World. Report of the Round Table on Aid for Aquaculture Development in the Third World, Norway, 2-6 August 1982. Rome: FAO.

(7) UNDP/FAO. Fish Quarantine and Fish Diseases in Southeast Asia.
1982 Report of a Workshop, Jakarta, 7-10 December 1988. Rome: FAO.

(8) Pillay, T.V.R. & Dill, W.A.(eds). Advances in Aquaculture.
1979 Papers presented at the FAO Technical Conference on Aquaculture, Kyoto, Japan, 26 May-2 June 1976. Surrey: Fishing News Books Ltd.

(9) FAO/IPFC. Preliminary Review of the State of Marine Pollution
1976 in East Asian Waters. Rome: FAO.

(10) FAO/UNEP. Assessment of Oil Pollution and Impact on Living
1980 Aquatic Resources in Southeast Asia. Rome: FAO.

(11) Sasekumar, A. The Value of the Mangrove Ecosystem and its
1977 Pollution Problems. Fifth FAO/SIDA Workshop on Aquatic Pollution in Relation to Protection of Living Resources, Manila, 1977. Rome: FAO.

(12) FAO. A Study of Methodologies for Forecasting Aquaculture
1984 Development. FAO Fisheries Technical Paper No. 248.

(13) FAO/EIFAC. Report of the Working Party on Stock Management
1984 Rome: FAO.

8. GENETIC RESOURCES

Genetic variability is the basis for plant and animal improvement. Until the beginning of this century, plant and animal genetic material of value to man was selected in an arbitrary way. However, because of advances in the field of genetics, scientists can now tailor varieties to suit different eco-climatic conditions and human needs. Unfortunately, the natural habitats where much of the genetic variability occurs are being eroded or destroyed, making the conservation of genetic resources a matter of extreme urgency.

8.1 CROP GENETIC RESOURCES

The swing to a technology-based agriculture threatens not only landraces but also their wild progenitors and weedy relatives - a large, untapped but potentially valuable source of genetic diversity. The need for wider genetic bases in plant breeding is now realized and there is a growing awareness that crops bred on a narrow genetic base do not have the same protection against diseases as the multitude of genotypes in a primitive crop. Annex Table 12 shows the regions of diversity of some crops and their wild relatives in the Asia and Pacific.

In 1983, the FAO Conference adopted a resolution launching an International Undertaking on Plant Genetic Resources (1). The Undertaking urges governments to safeguard plant genetic resources and ensure their unrestricted availability, and foresees intensified international cooperation to strengthen the capabilities of developing countries to survey and safeguard their own resources, to breed improved crop varieties and to develop their seed production and distribution systems. At the heart of the Undertaking is a commitment to develop, under the auspices of FAO, an internationally-coordinated network of national, regional and international centres, to hold collections of plant genetic resoures for the benefit of the international community.

Many domestic crops are now threatened by erosion of their genetic variability, mostly due to the inroduction of competing crops. The onion's genetic diversity in the Third World is being eroded due to commercial imports. A similar problem faces such crops as rice, sugarcane and Chinese cabbage. (2)

The International Board for Plant Genetic Resources (IBPGR), with a secretariat at FAO, was set up in the early seventies to safeguard, through a global network of genetic resources centres, the genetic variation of cultivated plants of major importance and to ensure their speedier availability to breeders. Collection priorities were set for crops and regions. In the earlier phase, even when the origin and evolution of a particular crop was known, the patterns of variation and distribution in the field were far from clear, and rates of genetic erosion were frequently mere guesses. By 1980, however, the Board was in a position to develop a global plan of action, which is revised each year, based on the experience gained in the previous year.

Wheat illustrates one of the problems enountered. The extent and scope of existing collections was not known, nor how much wild and primitive material they contained, though it was suspected that most of the samples were recent cultivars or breeding lines. Neither was the extent of duplication between collections known, nor the taxonomic spread of the samples. A survey completed in 1980 showed that many species were poorly represented in many major collections. A decade before, it was thought that there were more than 250 000 samples in wheat collections, whereas the survey showed that there were no more than 150 000. From this and other surveys, it was concluded that no major crop had been thoroughly collected.

A survey of storage facilities, carried out in 1975, revealed that only eight institutes in the world had facilities for the long-term storage of seeds. By 1982, the number had risen to 33. In 1983, there were 38 gene banks in 29 countries, holding collections of 30 crop species for long-term storage; 83 countries and approximately 150 institutions were active in the collection, characterization, documentation, conservation and exchange of plant genetic material. Present indications are that about 50 base collections will form a reasonably complete network to cater for about 40 major crops or groups of crops.

There are 14 centres in Asia and the Far East, and 3 in the Pacific holding collections which include major staple cereals, legumes, vegetables, oil seeds, root crops, banana and plantain. All countries in Southeast Asia have programmes on plant genetic resources. Bangladesh, China, India and Pakistan have programmes in existence or planned. (Annex Table 13)

At the international level, emphasis is given to the characterization and documentation of collected materials. This research is costly and requires land, facilities and manpower for growing out materials. (3) The IBPGR is planning to slow down wide-range collecting and consolidate research on materials already gathered, so that samples held in collections can be put into an orderly fashion. This will allow better estimates of the patterns of variability and identification of redundant duplicates.

Work has started on the collection of wild species and forage crop germplasm. The amount of germplasm of wild species held in gene banks is extremely low, yet important from the biological point of view. In the case of forage germplasm, emphasis will remain on the arid zones and tropical species.

8.1.1 Regional and crop priorities

High priority is assigned to a region if it has significant genetic diversity of one or more crops or species which are on the verge of extinction, or if it is subject to widespread crop failures causing loss of genetic diversity.

The IBPGR has identified fourteen regions in the developing world, consisting of groups of adjacent nations with broadly similar geographical conditions. Those is Asia and the Pacific are: South Asia (Bangladesh, Bhutan, Burma, India, Nepal and Sri Lanka), Southeast Asia (Indonesia, Malaysia, Philippines, Papua New Guinea and Thailand), East Asia (China, Democratic People's Republic of Korea, Republic of Korea, Japan and Mongolia) and the Pacific.

South Asia has been given first priority because of the rapid replacement of large areas of traditional cultivation and the wide variability in the region. Priority 1 crops are: rice, minor millets, Asiatic Vigna species, oilseed, Brassica, jute, eggplant, chillies, cucurbits, citrus, mango, banana and medicinal plants. Priority 2 crops are: maize, wheat, soybean, Dolichos spp., sesame, cotton, sweet potato, yam, ginger, betelvine, Piper spp. and tea.

In Southeast Asia (a second priority area), the following crops have priority: rice, maize, groundnut, soybean, winged bean, mungbean, rambutan, durian, mango, banana, citrus, Artocarpus spp., lansium, cashew, mangosteen, amaranth, bitter gourd, eggplant, Capsicum annum, Ipomea aquatica, yardlong bean, Brassica, sweet potato, yam, taro, Zingiberaceae, cinnamon, pepper (Piper spp.), clove, coconut, sugarcane, cotton, mulberry, Phili nut, various indigenous species of vegetable, and forage legumes, especially Desmodium, Cajanus, and allied genera, Calopoginium and Gliricidia, Stylosanthes sundaica, Glycine wiglitti, Canavelia rosea, Zornia diphylla, Aeschynomene, Vigna unguiculata, Alysicarpus vaginalis, Crotalaria spp., and Sesbania.

East Asia (which has been elevated from third to second priority) is the centre of origin of important crops such as, millet, oats, soyabean, tea and several forms of barley.

Many important economic and subsistence crops,particularly root crops, originate in the Pacific islands (a third priority region). Vegetables form up to half the daily food intake of much of the population. The variety of vegetables consumed in the Pacific islands is greater than in any other part of the globe.

A Symposium on Crop Genetic Resources for the Far East and the Pacific (4) held in 1980, recommended the following priorities for crops:

East Asia Region

Priority 1: wheat, rice, soyabean, chinese cabbage and Brassica.
Priority 2: barley, maize and tomato.
Priority 3: sorghum, potato, sweet potato, leek (and allies), cucumber and other cucurbitaceae, oleijerons Brassica, citrus, mulberry and tea.

Pacific Region

Priority 1: rice, aroids, sweet potato, cassava, yam, winged bean, aibika, coconut, banana, sugarcane and pandanus.
Priority 2: groundnut.

Amongst cereal crops, wheat has been accorded high priority because it is the staple food for 35% of the world's population. It accounts for more than 20% of calories consumed and contains many essential nutrients. With improvement in the amount of wheat germplasm collected, the emphasis is shifting toward the post-collection phases of work. These include maintenance and regeneration, documentation, evaluation and seed distribution. Considerable progress has been made in the collection of sorghum and pearl millet germplasm from the centres of diversity in India. The world collection at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India contains 22 500 sorghum and 15 500 pearl millet accessions.

In 1983, a Workshop on the Conservation of Rice Germplasm, reviewed progress made since 1977 in the collection and conservation of rice genetic resources, and developed a plan of action for 1983-87 to assemble the uncollected germplasm from around the world. A previous workshop, had formulated a five-year plan of action (1978-82) which led to the collection of 13 400 seed samples from 14 countries in Asia. Because of the collaboration of various national institutions, the International Rice Research Institute (IRRI) in the Philippines received an additional 16 500 accessions. (5)

Conservation of legume germplasm is extremely important. At present, grain legume yields are well below optimum levels, especially in comparison to cereals. Whereas genetic erosion was most marked in cereals, since the mid-1960s erosion has advanced into the traditional legume areas. ICRISAT holds a major collection of chickpea, pigeonpea and groundnut. Most samples have been characterized and evaluation data computerized. Sizeable collections of mungbean and winged bean now exist in a number of Asian countries.

The emphasis in international genetic resources work in the past has been on the major staple foods, viz. cereals, food legumes and, to a lesser extent, root crops. However, in recent years many more crops have been included. Horticultural crops in general, and leafy vegetables in particular, have not until recently received the attention they deserve. Possibly over 1 500 species of wild and cultivated plants in the tropics are leafy vegetables. Most are not well known or widely distributed and have limited potential.

Production data on leafy vegetables are more difficult to find than data for other horticultural crops. In general, consumption of leafy vegetables is low in the tropics, especially considering that vitamin A requirements often depend on these vegetables. They have low economic value and social prestige. The most important market vegetables are Chinese cabbge, amaranth, jute, taro, kangkong, Solanum spp., lettuce and spinach beet. (6)

There are two principal reasons for genetic erosion in leafy vegetables: the introduction of modern cultivars (e.g. Brassica spp. and, to a lesser extent, Amaranthus spp.) and European-type vegetables. Genetic improvement programmes have concentrated on temperate leafy vegetables. With the exception of Amaranthus, little has been done to improve tropical leafy vegetables. The IBPGR has assigned high priority to eight groups of vegetables, among which are Brassica and Amaranthus. A lower priority has been assigned to other vegetable crops (including many leafy vegetables), as it is assumed that they will be covered by regional and national programmes.

Some plants are a source of medicaments and were among the first to be used by man. The principal botanical drugs used in world trade are Chinchona, Dioseorea, Foxglove, Ginseng, Gentian, Psyllium, Opium, Senna, Rauvolfia, Cathranthus, Belladonna, Aconites, Aloes, Ammi majus, Pyrethrum, Renbane, Ipecac, Liquorice, Rhubarb, Nux-Vomica, Stramonium, Valeriana, and Vinca. Most are gathered from their wild habitats but some are cultivated, especially in India, Republic of Korea, China, Nepal, and Indonesia. Medicinal plants are used mainly for their phytochemical properties or as a source of drugs, rather than as a source of genetic diversity. Several plants, particularly those in accessible forest ranges, are in danger of extinction. (7)

8.2 ANIMAL GENETIC RESOURCES

It is surprising how few animal species have been domesticated by man: less than twenty. Within these species there are many breeds, races or strains, which contribute to genetic variation. This variation has slowly evolved as breeds or local populations accompanied human beings on their emigration around the world. As movement was slow, adaptation to many environments was possible. (8)

In general, livestock in tropical regions are less productive than those in temperate areas. They are smaller and have lower yields of milk, wool and meat. The introduction of temperate genotypes into the tropics is usually not a success: the animals either do not survive, do not breed, or their performance is much poorer than in their country of origin. Tropical animals increase in size and performance when well fed and protected from disease, but their output does not reach that of the temperate genotypes. In these circumstances, there are several options: improvement in environment, improvement in genotype (by selection within local breeds, introduction of exotics or crossbreeding between exotic and indigeneous breeds or both). The choice will depend on local conditions.

In many developing countries, breeds of livestock have evolved which adapt well to severe local environmental conditions. Among the important adaptive qualities are: resistance to diseases and parasites, the ability to survive and reproduce in hot dry, or hot humid, environments, and the ability to exist on low-quality and often scarce food with limited water. Increased animal production is not necessarily obtained by importing exotic breeds, and indiscriminate crossing of indiginous with exotic breeds is unwise.

The rapid introduction of new gentoypes from different environments poses several dangers. As it is now possible to move large numbers of animals by air or ship, rapid breed substitution is possible and locally-adapted breeds can be completely replaced. Crossbreeding, although not so rapid, also leads to changed genotypes. There is not sufficient knowledge to predict which genes, accumulated over years in adapted animals, will not be needed again. Such resources, even though not of immediate economic value, should be conserved. The problem is to resolve the conflicting needs of maximizing animal production now, and of conserving genetic resources for the future.

A technical consultation on the Conservation and Management of Animal Genetic Resources held in Rome in 1980 (9) recommended the development of a methodology to establish regional data banks for animal genetic resources. The purpose of data banks is to provide a comprehensive and accessible description of the characteristics of each breed and established crossbreeds of livestock and birds, together with characteristics of the environments to which they are adapted. This includes traits for the food, fibre or work products of the animals concerned, in addition to physical features. The information is then used to identify breeds which are at risk of extinction, so that preventative action may be taken.

The concept of conservation by gene bank is complex. Live animals can be preserved in situ, or in a semi-artificial situation. Alternatively, there can be cryogenic storage of sperm, fertilized ova or other tissues, or gene segments. There are economic problems with both live animals and haploid or diploid cells. There are also problems regarding how many to preserve, for how long, and where, especially in developing countries.

Much of the information on the distribution, numbers and production performance of various breeds, strains and varieties of livestock in Asia and the Pacific is unpublished, or, if published, is only available in local languages.

The water buffalo needs particular attention. There are some 130 million head in the region, comprising a large proportion of the world's population. They may be divided into the river type of the Indo-Pakistan sub-continent, which supply milk, meat and labour, and the swamp-type of East Asia, which is the major work animal and also contributes large amounts of meat. There are several breeds and strains within each type, but little is known about their relative merits.

The spread of Western Europe's improved dairy cattle breeds is affecting local breeds in Asia. Zebus under long-term threat include Sahiwal, Red Sindhi, Tharparkar and Gir from India and Pakistan. The zebus of Southeast Asia include the local cattle of Burma, Thailand, Kampuchea, Lao, Viet Nam, Malaysia, Southern China, the Philippines and Indonesia. They are extremely poorly described. In many places, because of their small size and low milk yield, they are not even considered suitable foundation stock for crossing with European dairy breeds, for which purpose imported Indian zebus are preferred. Description, census and evaluation (especially in systematic cross-breeding) are urgently needed. (10)

Bali cattle are particularly interesting because they and the buffalo are the only species of the family Bovidae to have been domesticated in the tropics. Their wild ancestor, the banteng Bos (Bibos javanious), at one time found in Southeast Asia from Manipur to Burma, is now reduced to a few thousand scattered populations, chiefly in reserves in Burma, Thailand, Indochina, Borneo and Java. Its survival is threatened by destruction of habitat, hunting and military operations. (11)

There are about one million domestic Bali cattle. They have been successfully exported to other regions of the wet tropics. Since cross-breeding is forbidden on Bali, the island acts as a source of purebred female foundation stock. As it is the breeders in other islands who benefit, it would seem fair that the producers on Bali be subsidized for breeding purebreds. When crossed with ordinary cattle, most of the hybrid males are sterile.

In the humid tropical region of Southeast Asia, prolific sheep breeds are found in Java, where the Priangan and East Java Fat-tail are coarse-wooled breeds which, with an 8-month lambing interval, can average three lambs per year. There are a number of interesting breeds in the sub-tropics. The Hu-yang of China has good litter sizes, and can lamb three times in two years. These breeds should be protected from indiscriminate crossbreeding and be selected for prolificacy and meat production. Centres for the study of prolific sheep should be established in order to compare the characteristics of different breeds in temperate, subtropical and tropical regions. The Han sheep of Shantung, and the Hu (or Wusih) sheep of Shanghai are exceptional in their prolificacy - over two lambs at a birth and three lambings in two years. Because they are kept on a household scale, population is not high.

In spite of their immense importance in developing countries, goats have been little described and what studies there are tend to describe the more common rather than the rarer breeds. But there must be many populations of unnamed local goats making an important contribution to the diet

of the subsistence farmer. A study from China shows that in Manchuria and Inner Mongolia, local goats have become practically extinct, save for a few females still seen in the Gobi. Their breeding area has been taken over by the Cashmere goat. In Southern China, the local, black, short-legged goats have become rare due to Jamnapari stock imported from India.

Minor species of farm livestock have been little studied. There are no textbooks or monographs devoted to the donkey, no research on its physiology, productivity or working ability; no experiments to increase its performance. A large proportion of the world's donkeys live in Asia where they are of vital importance as working animals. Next to the camel, they are the farm animals best adapted to a hot, dry environment.

Slightly more is known about camels. One fifth of the world's camels are found in India, Pakistan, Afghanistan, China and Mongolia. Because of its adaptation to an arid environment, its ability to live on plants inedible for other species, its economy in utilizing both water and protein, and its efficiency as a draught animal, the camel is vital to the economy of Northwest India.

8.3 WILDLIFE GENETIC RESOURCES

Wild relatives of domestic animals can provide valuable genetic diversity. Crossing domestic animals with their wild relatives can provide advantages such as greater size (for meat or work), increased leanness (fat being rejected by sophisticated taste), or resistance to disease or to climatic conditions. Other benefits depend on the hybrid vigour obtained by crossing two varieties of a species which have been genetically separated for generations. (12)

Attempts have been made to increase the hardiness of cattle by crossing with yak and bison. Unfortunately, the first-cross males are infertile so no new breed has been formed from these crosses. However, this does not mean that no such breed will be formed in the future. The Madura cattle of Indonesia appear to have arisen from a cross between cattle and banteng, although again the first-cross males of these two species are infertile.

The value of wild species as genetic resources gives added urgency to the cause of wildlife conservation. All wild cattle species are threatened, and wild horses, asses and camels are nearly extinct. The wild ancestors of other farm animals still survive, but all are under pressure, with the possible exception of the jungle fowl (_Gallus_ spp.). The first priority is, therefore, to conserve them. They should either be protected _in situ_, or be placed in national parks or other protected areas. The following ancestral species of large domestic mammals are in need of conservation (all are classed as "vulnerable" by IUCN, with the exception of the yak which is "endangered"):

Wild species	Domestic descendant
Banteng (_Bos javanicus_)	Bali cattle
Gaur (_Bos gaurus_)	Gayal or mithun
Yak (_Bos mutus_)	Domestic yak
Arni (_Bubalus arnee_)	Water buffalo
Bezoar (_Capra aegagrus_)	Domestic goat
Wild boar (_Sus scrofa_)	Domestic pig

Species closely related to domesticated mammals include the kouprey (*Bos sauveli*). The Cambodian kouprey, which has become rare, is the most primitive of living cattle, with features typical of some pliestocene forms. It could be of great significance for evolutionary studies of the genus *Bos*, which is the same as today's domestic breeds. The kouprey is said to be resistant to rinderpest, so crossbreeding between kouprey and domestic cattle could be significant in developing new breeds suitable for local conditions.

Feral animals (those which have escaped from domestication and returned to the wild) can undergo some selection in captivity to increase their productive characteristics; on return to the wild, they develop the self-sufficiency and environmental adaptation of the truly wild animal. They are thus intermediate between wild and domestic animals and so constitute a particularly interesting source of genes for improving breeds which have lost their environmental adaptation. (12)

The Asian elephant is a special case. It is a domesticated work animal, used in the timber industries of many countries. But the majority of working animals are caught in the wild and trained in captivity. The catastrophic decline in wild elephant numbers caused by the destruction of forests has left the demand for elephants exceeding supply. National parks and other protected areas cannot be a source until their numbers have recovered. Thus, in spite of the apparently high numbers of wild elephants, they are classified as "endangered". Most Asian governments have either completely banned or have strictly controlled their capture.

Table 8.2 Wild elephant populations in Asia

Location	Number
South India (Tamil Nadu, Kerala, Karnataka)	4 500
North India (U.P. Bihar, Orissa, West Bengal)	1 400 - 2 500
Northeat India, Bhutan and Bangladesh	4 000 - 8 000
Borneo	2 000
Burma	5 000
Indochina (Laos, Kampuchea,Viet Nam)	3 500 - 5 000
Malaya	3 000 - 6 000
Sri Lanka	2 000 - 4 000
Thailand	2 500 - 4 500
Others	500

Source: Ref. (13).

The mobility of wild animals poses problems for *in situ* conservation. This is particularly true of migratory animals (e.g. birds and some hoofed mammals), and of pelagic species (e.g. marine turtles and seals) that may breed on land or in the territorial waters of one country, but spend most of their life cycle elsewhere.

The conservation of wild animals *ex situ* is practised in many zoological gardens and national parks. However, genetic adaptation to an unnatural environment, together with a break in the continuous process of evolution through natural selection, could destroy the value of the genetic resource itself.

8.4 FOREST GENETIC RESOURCES

Tropical forest ecosystems supply many staple foods and contain wild relatives of modern food crops important for future breeding programmes. They are among the world's richest environments for species diversity and, at the same time, among the most vulnerable. They include many plants of potential industrial and medicinal importance whose usefulness should be investigated before their habitats are destroyed.

The rates of loss of variability for most plant species is either unknown or poorly quantified. While there are changes due to non-human factors, the vast proportion of current loss of forest genetic resources is caused directly or indirectly by the activities of man, due especially to increasing population pressure on wildlands, changing land-use patterns, and increases in mono-species plantations which have low genetic variability within the species. (14)

In India, 18 endemic tree and shrub species are reported to be in danger of extinction or depletion, including Pinus bhutanica, Popolus gamblei, Rhododendron dalhousiae and Salix bhutanensis. (15)

Domestication, in the form of managed plantations, should be accelerated, as well as conservation of threatened populations in situ. Domestication and breeding to meet short-term production objectives is likely to lead to a narrowing of the genetic base. A wise breeding strategy includes long-term maintenance of genetic diversity for its insurance value, for continuous use to enrich the genetic material in breeding populations, and for short-term breeding for specific and sometimes transitory purposes. Forestry has the advantage of still being primarily concerned with "wild" species, with a large proportion of the original variation still available; thus there are more options, and full account can be taken of conservation aspects in the domestication process.

An expert consultation, held in FAO in 1981, recommended that governments make specific mention of genetic resource conservation in statements on forest policy, and that conservation be included in the management plans of forest services, national parks authorities and others responsible for managing forest land. (16) The consultation concluded that the wide variation in the complexity and successional status of ecosystems, the breeding habits of species, and the political, social and financial constraints, prevented the adoption of any single general strategy for conservation.

Forest genetic resources may be conserved either in situ or ex situ. The former, as part of the natural ecosystem, is more desirable, provided that the area can be given full protection and that the resources are available for collection and use both within and outside the country. Individual species in tropical moist forests, often found in low densities and of unknown potential, can generally only be conserved in situ, since neither seed storage nor plantation techniques are known for most of them. On the other hand, the biological and technical knowledge for management of mixed tropical forests is often insufficient to deal with such fundamental aspects as desirable size and location of in situ reserves, the number of individuals constituting a viable gene pool, or to monitor the success achieved in safeguarding intraspecific variations. Research is therefore required on these species. A guide to in situ conservation of genetic resources of tropical woody species has been prepared within the framework of an FAO/UNEP project on the conservation of forest genetic resources. (17)

The need for in situ conservation of genetic resources has been recognized for many years in India and has found expression in the system of "preservation plots". By 1975, 163 representative examples of natural forest types, and 25 of plantations, mainly of indigenous species, were selected and designated. Natural forest plots range from a few hectares to 4 000 ha. The "preservation plots" system has been absorbed into the National Bureau of Forest Gene Resources, which will cater for both in situ and ex situ conservation.

Malaysia has one national park, 23 wildlife reserves and sanctuaries and 80 virgin jungle reserves ranging in size from 2.5 ha to 1 600 ha. (18) Only the virgin jungle reserves have so far been used for in situ conservation. Unfortuntely, their distribution in the Peninsula does not coincide with the ecotypic and genotypic variation in forest species.

The main problems in establishing in situ conservation areas in the region are inadequate funds and institutional support, lack of planning for the placement of conservation sites, and poor management of the species to ensure its preservation. Trained resource managers are scarce and there is insufficient knowledge of the biology and genetic variability of the various species.

The objective of ex situ conservation is to safeguard genetic material which is threatened in its natural ecosystems and which cannot be safeguarded in in situ reserves. For species for which seed storage, nursery establishment and management practices are known and for which in situ conservation is not feasible, ex situ conservation is a realistic approach. Conservation stands can be established in areas more secure than natural forests, protected against human pressure, fire, grazing and cultivation and managed for the preservation of its genetic divertsity. To this end, FAO has contributed to the collection of seed from provenances of a number of species which, at least in part of their ranges, are in danger of genetic depletion.

In India, 8 ex-situ stands were established by 1982 under the FAO/UNEP project on conservation of forest genetic resources. They covered a total area of 44.5 ha with Pinus caribaea and P. oocarpa. In Thailand, 21 stands were established by 1981, totalling 111.4 ha of land. The species were P. caribaea, P. occarpa, and Eucalyptus camaldulensis. (19)

The ultimate aim of genetic conservation is the sustained utilization of available resources. The FAO Panel of Experts on Forest Genetic Resources has coordinated global action in forest genetic resources over the last decade. Priority was given during the first few years to fast-growing species for industrial plantations (e.g. tropical pines, teak, Gmelina) in the moister areas of the tropics. More recently, emphasis has shifted to lesser-known species which provide a range of goods and services, especially for rural populations.

Through work on industrial tree species, valuable lessons were learned about the risks involved in transferring the results of research from one region or area to another, and in relying on too narrow a range of species or a restricted genetic base within a species. This knowlege is being applied in the field of social forestry, where the situation often parallels that of industrial forestry, as it was 25 years ago. Despite some success, it is evident that large areas of plantations and woodlots are not based on optimal genetic material. Cooperative, internationally-coordinated programmes should be established to provide

basic information and know-how on a range of species for varying environmental conditions and end uses. Unless urgent action is taken, there is a danger that social forestry programmes will be frustrated by lack of suitable genetic material.

A related problem is the impact of introduced species on local habitats. In many countries, exotic species are not pre-tested to ascertain their behaviour in the new habitat, particularly their aggessiveness and competative ability compared to local species. An example is a species of Prosopis, which has spread spontaneously beyond its point of introduction in India and Burma, and tends to dominate the community. This problem is particularly serious with regard to species native to arid zones that are planted in humid areas. FAO, in collaboration with the International Union of Forestry Research Orrganizations (IUFRO) has set up a special commission to develop guidelines on the introduction of exotic species.

8.5 FISH GENETIC RESOURCES

The need to conserve fish genetic resources has become more urgent with the progressive overfishing of natural stocks, large-scale alterations to river systems and the domestication of species through aquaculture. Since only a few of the 25 000 species of fish have been subjected to scientific scrutiny, the extinction of a species, apart from being an irreparable loss of genetic material, represents a potential loss of economic resources.

A World Symposium on Warm-Water Pond Fish Culture, organized by FAO in 1966, recognized the importance of genetic selection and hybridization to improve fish varieties for culture, and the need for an international system for designating strains and stocks. In 1976 a World Conference on Aquaculture drew attention to the adverse effects on indigenous stocks of the indiscriminate transfer of fish and shellfish, reaffirmed the need to maintain genetic diversity in artifically propagated stocks, and called for increased research in fish genetics to facilitate selective breeding programmes. (20)

While habitat destruction in the oceans is not yet appreciable (at least no significant increase in species extinction rates has been observed), other aquatic habitats are deteriorating rapidly. Human activities are causing erosion of genetic variation and extinction of species. The construction of dams and other obstructions on rivers where migratory species occur disrupt the biological and reproductive cycles of fish populations. Dams not only prevent migration to upstream spawning grounds, but can also change rivers into semi-lacustrine habitats, unsuitable for stream species.

Ecological barriers are also common and may be caused by pollution in the lower reaches of rivers which prevents the migration of various species. Artificial selection and domestication can result in conscious or unconscious inbreeding and genetic impoverishment. Certain species of fish are being introduced into lakes and rivers for use in control of weeds, vector-borne diseases and insect pests. While this is socially and economically desirable, attention should be paid to the effects on indigenous fish populations. Introduction of exotic species may lead to disease and higher levels of predation resulting in the extinction of, or at least changes in, the endemic species.

Fish is an important source of high-grade animal protein. With a growing world population and rising living standards, the pressure on fish as a source of food, and for its byproducts, is increasing. However, the

potential for further growth of natural marine and freshwater fisheries is limited. The total world harvest is 15 to 20 million tonnes lower than it might have been had fishing been managed sustainably; and already 25 marine fisheries have been severely depleted by overfishing. (21)

Certain species of fish with special or unusual biological features are useful for experimental, biochemical and pharamacological purposes. Substances isolated from fish and other aquatic animals are widely used in medical research. For example, tetradotoxin (TTX), a toxin isolated from the puffer fish (Tetraodon immaculata) is used in neuro-physiological research as a sodium channel blocker and is playing an important part in reaching an undertanding of the basic ionic mechanisms of nervous transmission.

Aquaculture is still in a relatively early stage of development and the production of new strains and races of food fish require careful management of genetic resources. As in the case of crop plants and domestic animals, extensive breeding leads to an inevitable narrowing of the genetic base. The genetic determinants likely to be lost in the early stages include those controlling resistance to disease and fitness in marginal environments. Breeders should therefore bear in mind the need to protect and preserve, at an early stage, the broad genetic diversity within those species most likely to be used for intensive breeding purposes.

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(1) FAO. Plant Genetic Resources: Report to the Director-General.
1983 22nd Sssion of FAO Conference, November, 1983. C83/25.

(2) Mooney, P.R. The Law of the Seed in Development Dialogue,
1983 1983:1-2.

(3) Williams, J.T. Crop Genetic Resources for All. Rome: IBPGR.
1983

(4) IBPGR. Symposium on the Genetic Resources of the Far East and the
1981 Pacific, October 1980, Japan.

(5) IRRI/IBPGR. Report of Rice Germplasm Conservation Workshop.
1983 Los Banos: IRRI.

(6) van Sloten, D. Changing Priorities in Genetic Conservation: Leafy
1981 Tropical Vegetables, in Report of the FAO/UNEP/IBPGR International Conference on Crop Genetic Resources, 6-10 April 1981. Rome: FAO.

(7) Gupta, R. Genetic Resources of Medicinal Plants, in FAO/UNEP/IBPGR
1981 International Conference (ibid).

(8) Hodges, J. Review of the FAO/UNEP Programme on Animal Genetic
1983 Resources. Paper presented at the FAO/UNEP Training Course on Animal Genetic Resources, Budapest, September 1983.

(9) FAO/UNEP. Animal Genetic Resources Conservation and Management.
1981 Report of Technical Consultation, Rome, 2-6 June 1980. Rome: FAO.

(10) Mason, I.L. FAO/UNEP Pilot Study on the Conservation of Animal
1975 Genetic Resources. Rome: FAO.

(11) Mason, I.L. The Agricultural Potential of Minor Species of Farm
1981 Livestock in the Old World, in Animal Genetic Resources: Conservation and Management. FAO Animal Production and Health Paper 24. Rome: FAO.

(12) Mason, I.L. The Role of Protected Areas in the in situ Conservation
1982 of Animal Genetic Resources. Paper presented at World National Parks Congress, Bali, 18-20 October 1982.

(13) IUCN. Red Data Book. Gland, Switzerland.
1978

(14) Ingram, G.B. In Situ Conservation of Genetic Resources of Plants:
1984 the Scientific and Technical Base. Rome: FAO.

(15) FAO. Fifth Session of the FAO Panel of Experts on Foresc Gene
1984 Resources, Rome.

(16) FAO/UNEP. Report of the Expert Consultation on In Situ Conservation
1981 of Forest Genetic Resources, 2-4 December 1980. Rome: FAO.

(17) FAO/UNEP. A Guide to in situ Conservation of Genetic Resources
1984 of Tropical Woody Species. Prepared within the framework of FAO/UNEP Project "Conservation of Forst Genetic Resources". Rome: FAO.

(18) FAO. Forest Genetic Resources Information, No. 14. Rome.
1985

(19) FAO/UNEP. Final Report of the FAO/UNEP Project on the Conservation
1985 of Forest Genetic Resources. Rome: FAO.

(20) FAO. Report of Technical Conference on Aquaculture, Kyoto, Japan,
1976 26 May-2 June 1976. FAO Fisheries Report No. 188, Rome.

(21) FAO/UNEP. Conservation of the Genetic Resources of Fish: Problems
1981 and Recommendations, FAO Fisheries Technical Paper 217. Rome: FAO.

9. SOME MAJOR ENVIRONMENTAL PROBLEMS

9.1 SHIFTING CULTIVATION (1, 2, 3, 4)

Shifting cultivation has been condemned by many as responsible for increasing the area classed as "waste lands". For primitive cultures, it was a remarkable innovation, beinging a revolutionary transition from food gathering to food production. This was how mixed cropping for a self-sufficient subsistence economy developed and still thrives where there is a strong tradition of shifting cultivation.

Shifting cultivation, or slash-and-burn agriculture, is known by a variety of names (e.g. swidden, shag, kaingin, jhum, chena). In spite of certain similarities, the practices and consequences vary throughout the world. Differences in climate, topography, soil characteristics, methods of land preparation, population pressure, and the lifestyles of those who practise shifting cultivation all contribute to this variation. It is therefore difficult to define, although there is general agreement that the relation between cultivation periods and fallow periods is essential in any definition.

A FAO/UNEP project on tropical forest resources assessment has estimated the extent of shifting cultivation for most of Asia. (Data for China are not available). (Approximately 400 million ha of tropical lands are occupied by shifting cultivation and long-fallow agriculture (8.3% of the total land area). In Tropical Asia-Oceania, the amount is 73.25 million ha (7.7% of the total area). The percentage is low in heavily-populated areas of South Asia and in Tropical Oceania.

The percentage of forest fallow is highest in Burma, Kampuchea, Lao, Thailand and Viet Nam, where shifting cultivation is the dominant agricultural system of hill communities. Forest fallow areas have increased annually in the Tropical Asia-Oceania region by 1.3%, which is smaller than the agricultural population growth rate (1.5% in tropical Asia) (see Table 9.1 and 9.2).

Table 9.1 Estimated areas of forest fallow in 1980 (in thousand ha)

Region	Forest fallows closed	Forest fallows open	% of total area
South Asia (a)	10 950	SA	2.4
Continental Southeast Asia (b)	18 900	SA	15.9
Insular Southeast Asia (c)	22 040	3 900	10.2
Centrally-planned Tropical Asia (d)	15 950	30	21.2
Tropical Oceania (e)	1 410	70	2.7
Tropical Asia-Oceania	69 250	4 000	7.7
Tropical World	239 559	170 000	8.3

Source: Ref. (2)

Note: see Table 9.2 for footnotes.

Table 9.2 Estimated increase in areas of forest fallow (in thousand ha)

Region	Increase in forest fallows closed	open	% of 1980 area
South Asia (a)	230	SA	2.1
Continental Southeast Asia (b)	130	SA	0.7
Insular Southeast Asia (c)	330	30	1.4
Centrally-planned Tropical Asia (d)	200	SA	1.3
Tropical Oceania (e)	10	SA	0.9
Tropical Asia-Oceania	910	30	1.3
Tropical world	3 400	1 720	1.25

SA = Small area.

(a) Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka.
(b) Burma , Thailand.
(c) Brunei, Indonesia, Malaysia, Philippines.
(d) Kampuchea, Lao, Viet Nam.
(e) Fiji, New Caledonia, Papua New Guinea, Solomon Islands, Samoa, Vanuatu.

Source: Ref. (2)

9.1.1 Shifting cultivation in some countries of the region

Shifting cultivation is mostly practised in Southeast Asia, particularly in Kalimantan (Indonesia), Northeast and Central India, central highlands of Viet Nam, Sabah and Sarawak (Malaysia), Mindanao (Philippines), Lao and parts of Burma, Thailand, Bangladesh, and Papua New Guinea.

In India, shifting cultivation is practised over an area of one million ha involving some 2.7 million people. Degradation of soils is greatest in the central and coastal States, where rainfall is low, population density high, soil poor and fallow periods shorter than in the wetter, less populated, northeast States.

In Thailand, approximately 350 000 people are engaged in shifting cultivation. In many places primary forest has disappeared and a fire climax vegetation, such as Imperata cylindrica grassland, has developed; an estimated 4 million ha are covered by Imperata.

Shifting cultivation in Indonesia is confined mostly to Kalimantan, Sumatra, Sulawesi, Maluku and Nusatenggara, where an estimated 2 million families (12 million persons) subsist on it. Most of the areas have been reduced to poor secondary forests, converted to Imperata grassland or rendered bare. Over 16 million ha suffer from lack of fertility and soil cover.

In Sabah (Malaysia), an estimated 1.4 million ha were under shifting cultivation in 1980, involving 390 000 persons, mainly from the Iban tribe. In Sarawak, the estimated figures for 1980 were 3.3 million ha under shifting cultivation, involving 280 000 people.

9.1.2 Some systems of shifting cultivation

In traditional systems, land use is adjusted to the inherent soil properties, with longer fallow periods for poorer soils. However, as populations increase, land becomes scarce, the fallow is shortened and more intensive use is made of the land. Shifting cultivation is labour efficient, but adapts poorly to a market-oriented economy. When it is forced to become more intensive, it loses its stability.

All forms of shifting cultivation have varying impacts on tropical forests. Tropical forest ecosystems are damaged when cultivation is practised on unsuitable land; when there is ignorance or carelessness of the ease with which the ecosystem can be damaged, and failure to adjust practices accordingly; or when the people, although aware of the damage, are forced to exploit the ecosystem in order to survive.

Long-fallow or forest-fallow shifting cultivation is ecologically sound, leaving only small scars not unlike those from natural disturbances (floods, landslides, falling trees), which rapidly heal. The period of cultivation is short (1 to 2 years), the period of fallow long (about 20 years), and the fields are usually widely dispersed. Long-fallow systems support sparse populations, since only a small land area is utilized at one time.

Where fallows range from about 4 to 20 years, scrub and low forest regeneration may be adequate to restore fertility and moisture, improve soil structure and reduce weeds and pests to permit a renewal of cultivation. The ecosystem will only partially recover in terms of size of trees, species diversity and wildlife. The rate and composition of regrowth can be influenced by planting nitrogen-fixing legumes or fast-growing trees, such as Casuarina, as in the New Guinea highlands. Stable short-fallow systems are common in many parts of Asia among farmers who know the needs and limitations of their habitat and have adjusted their farming accordingly. Up to 50 persons per sq km are possible, but the system breaks down when the population increases.

Where the fallow is less than 4 years, it is dominated by grasses and shrubs, and the recovery of soils and woody vegetation is insufficient. Cropping becomes permanent or near permanent. Population density, labour inputs and production costs are high and, consequently, living standards are low. Degradation may be so severe that the land has ultimately to be abandoned. Natural fertility may be increased by mulches, composts, manures, ash, and sometimes manufactured fertilizers, and the soil structure can be improved by mounding and ridging and the elimination of weeds. Agricultural intensification and population absorption in one area may save other forest areas from being destroyed by expanding shifting cultivation.

The Taungya system of shifting cultivation has worked well in many parts of the world. Cultivators grow crops for a few years and plant commercially useful timber species. After the harvest, the residues are burnt in situ and the cycle repeated.

Jhum is a sequential agrisilviculture system, but the trees are not utilized for their wood, the emphasis being on the production of tree crops. There may be a shift in emphasis when alternative uses can be found for the forest resources but in general these resources are of little local value.

Improved methods of shifting cultivation in lightly populated areas include the corridor system, the introduction of new crop varieties, tree crops, conservation techniques, and improvement of fallow with leguminous

species. An intermediate solution is semi-permanent cultivation that requires fertile soils, or the frequent application of manure, and a carefully-managed sequence of crop/fallow rotation, with herbaceous fodder for grazing.

Agricultural research and extension have key roles to play in investigating and implementing alternatives to short-rotation shifting cultivation, including its substitution with permanent agriculture. Interrupting the natural recycling of nutrients by removing forest cover requires the use of costly artificial fertilizers to maintain soil fertility. Some experiments have been successful in using a minimum of ploughing and mulching, improving soils with vegetal wastes and practising polyculture but, at present, permanent tree crops or plantations (e.g. African oil palm) seem to provide the most satisfactory solution, as trees recycle their own nutrients.

The goal of tropical land management should be the development of sustained-yield agro-ecosystems. The most stable and least environmentally destructive systems are those which are integrated with perennials and livestock, i.e. permanent field systems in which annual crops are rotated with and within a multi-storied complex of trees and shrubs which include fruit, nuts, fibres, timber, medicinal and beverage plants, shade and ornamental plants, plus chickens, pigs and a few cattle. Natural conditions are reproduced as closely as possible, protecting the soil and permitting the maintenance of the nutrient cycle with manufactured fertilizers. Diversity is maintained which minimizes diseases and pests. Such systems, which exist more in theory than in practice, are only moderately productive and require a fair amount of labour, but they are not dependent on fossil fuels. They can provide adequate subsistence and some commercial production.

Technical assistance, incentives and market outlets are needed if a way of life formerly based on nomadic agriculture is to be replaced by a more stable type. Governments should encourage the establishment of alternatives to shifting cultivation.

9.2 DEFORESTATION AND DEGRADATION OF FOREST RESOURCES (2)

9.2.1 Deforestation

A serious problem in the Asia and Pacific region is the rate of removal of tropical closed-forest cover. "Deforestation" is used here to designate transfer or alienation of forest lands for non-forestry purposes.

During 1976-80, the total closed-forest area deforested in the region was 9 million ha, or 1.815 million ha every year. If this trend continues, by the year 2000 some 36 million ha will have been converted to non-forestry uses, amounting to a reduction of 12% in closed forests. Mean annual deforestation was highest in insular Southeast Asia (880 000 ha), followed by continental Southeast Asia and the Centrally-planned countries (633 000 ha), South Asia (273 000 ha), Papua New Guinea (21 000 ha), and Bangladesh (8 000 ha).

An increase in the rate of deforestation is foreseen in Sri Lanka (mainly due to the Mahaweli irrigation project), Indonesia, Malaysia and Kampuchea. A decrease is forecast for Thailand, Philippines (reduction of available and accessible forest land), Brunei and Lao. In other countries, deforestation is expected to remain stationary or increase slightly.

Table 9.3 Deforestation in the region (1976-1980)

Category	Mean annual area deforested (in '000 ha)	(%)
Logged-over, productive closed broadleaved forests	1 068	58.9
Undisturbed, productive closed broadleaved forests	483	26.6
Productive, managed closed broadleaved forests	106	5.9
Unproductive, closed broadleaved forests	110	6.0
Coniferous forests	35	1.9
Bamboo forests	13	0.7
Total	1 815	100

Source: Ref. (2)

Shifting cultivation, which follows in the wake of logging, is the principal cause of deforestation. Unorganized and spontaneous encroachments, squatting, migration by lowlanders - all manifestations of increasing demand for cultivable land by landless and unemployed rural poor - account for considerable deforestation. This form is most prevalent in the Philippines where the Bureau of Forestry Development is attempting to rationalize the classification of forest lands in favour of the landless. In Nepal, population pressure in the hills has caused migration to the Terai areas, and encroachment into forest lands. In Thailand, refugee influx and encroachment by local people has contributed to deforestation.

Organized forms of settlement, generally government-sponsored, are common in Indonesia, Malaysia, Sri Lanka and, to a lesser extent, Nepal. Under Indonesia's transmigration programme, 50 000 families were moved during 1974-1978 from over-populated Java, Bali and Madura to Sumatra and Kalimantan, and each family given 5 ha of land. The targst for the future is 25 000 families per year. In Malaysia, conversion of forest land into oil palm and rubber plantations is a State-sponsored activity, sometimes aided by international agencies.

In Sri Lanka, under the Mahaweli irrigation project, some 260 000 ha of forest will be converted to agriculture, for settlement. In recent years, forest land has been lost to irrigation and hydro-electric projects in almost every country, particularly India and Sri Lanka; and to mining in Thailand, Malaysia and Papua New Guinea.

9.2.2 Degradation

Logging operations in dipterocarp forests of the region are one of the main causes of degradation, especially in insular Southeast Asia, whose forests are one of the world's major sources of hardwood timber. In no other mixed tropical forests is logging so intensive. Valuable species may gradually disappear because of their inability to regenerate under the open canopy of the logged-over forests. Generally, the area bared by tractor tracks, skid trails and landings, does not revegetate rapidly; this can lead in hilly terrain, to erosion and landslides. However, the depletion is generally provisional if the forest is left to recover.

In Sarawak, it is estimated that temporary open spaces and bare soil (skid trails, roads, landings, etc.) account for as much as 40% of the logged-over area. This means that 60% of the area remained under standing forest after intensive logging. As many as 26 trees per ha of commercial species fall and an additional 33 are injured. Most damage is caused when big trees with large crowns are felled in the path of other trees which in turn fall on others, thus creating a domino effect. The loss due to logging is approximately 60 trees per ha, or 40% of the stock. In varying intensities, this type of degradation is seen in the 44 million ha of logged-over forests of insular Southeast Asia where mechanized logging is practised.

Another reason for the degradation of tropical forests is the demand for fuelwood. In Thailand, annual production of wood in 1980 was estimated to be 16 million m3, against a consumption of 28 million m3, of which 90% was fuelwood. The gap between consumption and production was primarily filled by unrecorded removals of forest, resulting in degradation.

The degradation of many forests in the region has been brought about by inadequate attention to the basic needs of rural people. On the one hand, under government patronage, forests have been exploited and produce sold at competitive prices in far-away markets. On the other, the people living near forests are denied legal access, or have such restrictions placed on them that they are unable to satisfy their needs for fuelwood, building poles, fodder, etc., without resorting to unorganized felling, excessive lopping of trees or overgrazing.

In a number of countries, large-scale commercialization is putting pressure on resources in remote areas. Charcoal manufactured from forests in one part of a country is transported to markets in another part, sometimes hundreds of kilometers away. Bangkok, with its 5 million inhabitants, derives much of its charcoal supply from forests in remote northern parts of the country.

In farming systems, particularly in South Asia, animals fulfill an essential role in the functioning and stability of rural economies. Grazing of livestock on pastures outside farm boundaries, particularly in forest areas, is traditional in several countries of the region. The extension of irrigated and cultivated land is leading to a decrease in the land available for grazing, resulting in reliance on forest areas and consequent degradation. In addition to depletion of vegetative cover, trampling by cattle hardens the soil, preventing forest regeneration and causing soil erosion.

Yet another agent of forest degradation in the region is fire. Most forest fires are caused for a specific purpose, to clear land for shifting cultivation, to facilitate collection of minor forest produce, or to smoke out bees and rats. In South Asia, forest fires are generally started by graziers to burn old grass and induce fresh shoots after the first rains. In the tropical high forest areas, repeated fire is responsible for far-reaching ecological changes. For example, the dominance of <u>Imperata cylindrica</u>, <u>Themeda triandra</u>, <u>Chrysopogen aciculstus</u> and <u>Capillipedium parviflorum</u>, due to the frequent occurrence of fires and overgrazing, is perpetuating a grass-fire-grass cycle and preventing plant succession in parts of the Philippines. Thus, the land loses its forestry potential, but has increased value and productivity in terms of livestock production.

There are many examples of degradation of both natural forests and plantations by insect pests. Defoliation and high mortality of <u>Shorea albida</u> over 12 000 ha of peat swamp in Brunei and Sarawak has been

Mass attacks by insect pests on sal and teak are recorded in India. In Thailand, pine-shoot moth caused serious damage to plantations of Pinus kesiya. In the Philippines, an unidentified borer attacked and destroyed some areas of Eucalyptus deglupta.

Natural disasters can also be a cause of forest degradation. A hurricane in 1963 destroyed nearly 200 000 large trees in south Thailand. In the Hanzeda/Bassein forest division of Burma, the evergreen forests were severely damaged by a cyclone in 1975. Typhoon damage to Philippine forests is a recurring phenomenon.

Mining concessions in forest areas have become common in recent years in several countries of tropical Asia. There is evidence that both mine waste dumps and tailing deposits are submarginal sites for plant growth and survival. Extensive forest degradation due to mining operations has occurred in Thailand, Philippines, Malaysia and Papua New Guinea. During the Viet Nam war, 1.25 million ha of forest were sprayed by defoliants, mangroves being the most affected species, and 4 million ha of forest was damaged by heavy bombing.

Depletion of vegetative cover and deforestation of watershed areas cause changes in patterns of river flows by diminishing water storage capacities. Increasing sedimentation following deforestation raises the risk of flashflooding. Both eventualities could lead to the depletion of soil.

If current trends in deforestation continue, the medium-term prospect is a decrease in forest growing stock, resulting in a progressive decline in global export potential of tropical wood products. This decline will be exacerbated by the combined effects of population and economic growth, which will translate into expansion of local demand for forest products, and will aggravate local shortages. Fuelwood scarcities, already a critical problem in less-forested areas, will spread.

Greater control over logging operations is needed, together with intensive management in the post-harvest period, increased reforestation, agroforestry, silvipasture, fuelwood plantations near populated areas, and rationalization of forest grazing, in order to arrest the process of degradation. However, progress in implementing these measures has been slow and has made little impact to date.

9.3 DESERTIFICATION

Desertification is the intensification or extension of desert-like conditions, leading to reduced biological productivity, with consequent reduction in plant biomass, in the land's carrying capacity for livestock, in crop yields, and in human well-being. This definition, adopted by the UN Conference on Desertification (1977), is much broader than the one normally used by ecologists, i.e. extension of the desert's climate (annual rainfall less than 100 mm) into humid areas. The UN definition (which does not consider climate) applies to areas that for various reasons (overgrazing, salinity or alkalinity, cultivation of marginal areas), lose their protective cover of vegetation.

Some foresters maintain that there is a link between deforestation and increasing aridity of the climate, but there is, as yet, no convincing data to prove such a link. Nevertheless, loss of vegetative cover (whether called "desertification" or "degradation") is a major cause of long-term decrease in the productivity of land.

The World Map of Desertification (5) indicates the hazards to which land is exposed if its over-exploitation continues, and also the level of degradation expected to afflict the vulnerable areas in prolonged drought conditions. Areas of extreme (climatic) desert in Asia cover 1.58 million sq km (3.6% of the land area). Some 0.79 million sq km (1.8%) are classified as having a very high degree of desertification hazard, 7.25 million sq km (17%) a high degree, and 5.61 million sq km (13%), a moderate degree (Table 9.4). In arid lands, a limit of 7 inhabitants per sq km and one animal per 5 ha are considered appropriate, and 20 inhabitants per sq km and one animal per ha in semi-arid zones.

Table 9.4 Extent of area affected by desertification in Asia and likely to be affected

Degree of desertificatin	(sq km)	(%)
Extreme desert	1 580 624	3.6
Very high degree of hazard	790 312	1.8
High degree of hazard	7 253 464	16.5
Moderate degree of hazard	5 607 563	12.8

Source: Ref. (5).

The Indus Plain in Pakistan illustrates some of the problems related to desertification. It has two main features: the alluvial plain (lying between the rivers Indus and Jhelumand), and the deserts of Thal, Cholistan and Thar (in the southeast). Most of the Cholistan and Thar deserts consists of ridges of drifting dunes piled up by wind. Vast tracts in these deserts are made up of scattered low, open natural forests of different species of Acacia and Prosopis, and other xerophytic species. This is the natural vegetation of most of the unirrigated Indus Plain. This tropical arid and semi-arid zone, covering millions of hectares, has an average annual precipitation of 150 to 220 mm.

In 1947, an extensive canal system was built to develop the Thal desert. In order to provide fuelwood and timber for the settlers, a well-planned programme of afforestation was started. Village forests of 20 ha were established in settlement blocks of 400 ha, which covered 1 800 ha, together with shelter-belts of trees along water channels and roads criss-crossing the desert. Over 0.19 million ha of irrigated plantations have been created. (6)

The rangelands of Pakistan, a national asset with immense potential for development, are intensively used for pastoral activities. Problems of afforestation/reforestation in these zones are diverse in nature and difficult to tackle. Besides the major handicap of low, erratic rainfall, other factors, such as low fertility, soil and wind erosion and the almost total disappearance of original vegetation have made dry afforestation a challenging task. Afforestation of wastelands in low rainfall zones has always been considered important in Pakistan, although in some cases the choice of species (unpalatable and of low forage value) has seriously reduced the productivity of the land for livestock production.

Although irrigation provides the most productive basis for agriculture in arid and semi-arid regions, India and Pakistan have had problems in areas where irrigation has caused waterlogging and soil salinity. Pakistan has successfully attempted reclamation, which has become part of the overall development plan of the country. Its experience in obtaining increased crop yields should be valuable to other countries with problems of a similar nature.

In India, a number of programmes are in progress to reclaim degraded areas and improve their productivity. The Indian desert is one of the most thickly-populated in the world, having in 1971 over 19 million people and an average density of 61 persons per sq km, as against 3 persons per sq km in most other deserts of the world. Despite the aridity, the potential of land, livestock, groundwater and vegetation resources is undeniable, and it is now realized that the Indian desert, is not so intractable a problem as was generally thought. The solution lies in planned exploitation, based on scientific data, and integrated resource surveys, to enable the optimum harnessing of resources. (7)

A survey covering 64 000 sq km of arid Rajasthan shows that land use is inconsistent with the inherent soil characteristics. Only 46% to 60% is suitable for farming, the remainder being dunes, highly susceptible to wind erosion, and hummocky plains or light-textured hardpan soil in danger of becoming barren on account of surface stripping. This area should be put under permanent pasture for sustained production and resource conservation. The Central Arid Zone Research Institute has establised trees, shrubs and grasses in western Rajasthan to arrest the movement of sand dunes

The success of sand dune stabilization depends on choosing the right species, and knowing how and when they should be planted. No grazing should be allowed within an afforested dune area. Cropping and other biotic interferences should be discouraged for a 10-15 year period. Grasses that have been established for two years may be harvested, preferably at the seeding stage. From the tenth year onward, the trees may be lopped for fodder or felled for fuel, the felling cycle being 10-15 years, depending on the growth of the trees. (8)

China has made significant progress in combatting desertification by the application of traditional knowledge and experience,and large-scale public participation, taking into account the special features of the environment. Shelter belts of trees and shrubs are planted around oases and farmland as a protection against sand drift, while windbreak networks are planted within the cultivated areas to protect the crop plants. Grasses are planted in the fringes of the surrounding desert to stabilize moving sand. Where possible, surface water is used for levelling dunes.

Where shifting dunes occur amid prevailing fixed and semi-fixed dunes, grass kulums (enclosed plots between dunes where water and soil conditions are favourable) are constructed to protect the land from grazing and other activities. Pastures are protected against desertification by stabilizing dunes through plantings, by fencing off ranges and by constructing protective forest belts. In most desert areas, new oases are developed on lake basins, on desert rims and on the banks of rivers extending into the deserts by building reservoirs to store the waters of intermittent floods and ditches to collect and divert runoff from mountain snow, and by tapping groundwater resources. In such oases, the land is levelled, shelter belts planted, soil quality improved and barren lands reclaimed. Along railways and highways that pass through deserts, engineering measures are adopted to stabilize moving sands. (9)

Mass movements to combat desertification have yet to be initiated in most countries. Public participation is a critical element. Dryland societies have an in-built capacity to cope with significant degrees of desertification. All the countries of the region need to strengthen their national scientific and technological manpower resources for combatting desertification.

In 1978, FAO in collaboration with UNEP, initiated a desertification assessment and mapping project. The methodology which emerged from this project was field tested in nine countries. Using this methodology, it is hoped to prepare a world desertification map, which will provide better scientific data for preparing programmes to combat desertification.

9.4 WATERSHED DEGRADATION (10)

The Asia and Pacific region supports over half the world's population, 50% of whom live in mountain areas experiencing serious environmental degradation. Population pressure in the uplands is leading to deterioration of watersheds. As a result, the other half of the population living in the plains suffers floods and droughts; waterways, harbours, reservoirs and water development schemes are affected by sedimentation. The entire economy of these drought-prone areas is subjected to periods of emergency, as mountain watersheds lose their capability to hold water and regulate river flow.

9.4.1 Himalayan-Tibetan mountain ecosystem

The Himalaya is the greatest physical feature and the youngest mountain system on earth. It stretches uninterruptedly for 2 500 km from west to east (through Pakistan, India, Nepal and Bhutan) and its width varies from 250 to 300 km. It is extremely vulnerable to soil erosion.

In India, the fuelwood and timber needs of hill people and plains people alike have to be met from local forests. Exploitation, both legal and illegal, is heavy. *Per caput* forest area was only 0.12 ha in 1971, as compared to a world average of 1.08 ha. Even if no further deforestation takes place, it is estimated that by the year 2000, only 0.075 ha of forest area *per caput* will be available, due to increasing population. The area affected by flooding has increased. Since 1953, floods have affected 4.9 million ha of land annually in Assam, Bihar, Uttar Pradesh and West Bengal, including 2.1 million ha of cropped land.

Over 80% of Nepal is composed of mountains and rolling hills. Some 29% of the land is under forest, of which at least one third is fair to poor, and 22% (3.1 million ha) cropped, 38% of which is in the hills. Of the 15 million population, 66% live in the hills. About 13% of the land area (1.8 million ha) is pasture land and 18% (2.5 million ha) is classified as barren land. More than 87% of energy is derived from forest produce. A decade ago, the forested area was 6.4 million ha, but is now only 4 million ha. In the Trisuli watershed, there was a reduction of 23% of forest cover during the period 1956-67.

Although Bhutan does not have serious problems of watershed degradation, the hazards are high, and current development of roads for exploiting pine forests, and large-scale logging operations located at high elevations, might lead to the problem of torrents faced by other Himalayan countries.

The Yellow River of China transports as much as 1.6 billion tonnes of sediment per year, of which 400 million tonnes is coarse grained; as a result of channel accretion, the river bed is raised an average 10 cm annually. The modulus of soil erosion is 50 to 100 tonnes per ha, reaching as much as 300 tonnes per ha. The upper and middle reaches of this river (5 464 km long and 752 000 sq km catchment) pass through the loess plateau (580 000 sq km), which has erosion problems unique to China in that 430 000 sq km are subject to degradation. Only 3% of the original forest vegetation remains. Owing to the severe loss of soil and water, further aggravated by droughts, farmlands in these reaches of the Yellow River have low yields. Sediment causes problems in the lower reaches of the river with its high population and insufficient cultivated land (0.1 ha/caput).

The Changjiang (Yangtze) River is 6 300 km long and has a catchment of 1.8 million sq km, of which 87% belongs to plateaux, mountains and hills and only 13% to plains. Vegetative cover is generally adequate. However, due to steep slopes, high rainfall, low permeability, cohesive soils, and unstable erodible parent rock, irrational land use has resulted in loss of soil and water. This has adversely affected agricultural production and contributed to siltation of reservoirs and channel aggravation, detrimental to farm irrigation and inland navigation.

9.4.2 South and Southeast Asia mountain ecosystems

Shifting cultivation with a short rotation cycle is a major cause of watershed degradation in these mountain ecosystems. Starting in India and moving east, shifting cultivation is practised in the mountains and hills of Bhutan, Eastern Nepal, Bangladesh, Burma, Thailand and Lao.

There is a variety of forests in Thailand. Teak is the main commercial crop and the dominant tree in the mixed deciduous forests. As a result of ancient shifting cultivation, large areas are covered with bamboos. At present 35% and 32% of the total land area is under permanent agriculture and forests respectively. Due to overexploitation, illegal encroachment, fires and shifting cultivation, forest land has dwindled greatly during the last decade. Flood damage and sedimentation of river beds and reservoirs has significantly increased. A survey by the Land Development Department classed one quarter of Thailand's agricultural land as severely to very severely eroded.

Malaysia is hilly to mountainous, with steep slopes even on low hills. Soils are highly susceptible to erosion and top-soil fertility is rapidly lost on removal of vegetation. The natural vegetation is tropical rain forest which occupies 58% of the land area. Malaysia has abundant land and natural resources and a relatively low population of about 14 million. The development of new agricultural land is traditionally an important strategy in economic development. However, this cannot be continued indefinitely as much of the land is located in environmentally sensitive areas and vital watersheds. The rapid rate of forest depletion and logging in Malaysia has given rise to increasing soil erosion and degradation, water pollution, water shortages and floods.

In Burma, watershed degradation is adversely affecting yield of water for irrigation, thus reducing agricultural production. Siltation of small and large reservoirs is increasing and reducing the navigability of inland river transportation so vital in Burma. Floods affected the Mekong River plains in Lao in 1978 and 1980. Sediment is a major problem in the Mekong River and in a number of its tributaries. The sediment load of the river at the site of the proposed Pa Mong Dam, is 160 million tonnes annually.

9.4.3 Island mountain ecosystems

These ecosystems are found from the Indian Ocean (Sri Lanka) to the South Pacific Ocean (Samoa). The islands have extensive mountain ranges, and, except for Sri Lanka, which is a fragement of the ancient southern continent, are all volcanic in origin, and have high rainfall of 1 600 to 6 500 mm per annum; 60% to 70% of the populations are rural.

Sri Lanka has a forest cover of only 22%. Slash-and-burn (chena) agriculture, tobacco cultivation, overgrazing, illicit timber and fuel cutting, illicit gem mining, and tea estates are major causes of watershed degradation.

Indonesia, the world's largest archipelago, has 13 677 islands in the equatorial zone with a land area of 2 million sg km, half of which is under forests. More than 50% is mountainous and volcanic. Volcanoes influence vegetation, forests and soil, and are been the cause of much devastation of forest lands. It is estimated that 43 million ha (22% of the total) is unproductive, comprising degraded forests, Imperata grassland and eroded areas, nearly half of which (21 million ha) are categorised as critical areas. Only 21.7 million ha (11.7% of the total area) is suitable for cultivation.

The Philippines is an archipelago of about 7 000 islands with an area of 300 000 sq km. The islands have risen as a result of volcanic activity and nearly all have rugged interior uplands, rising from 1 250 to 2 500 m. Lowlands are scarce and coastal plains rarely exceed 15 km in width. The major causes of watershed degradation are population pressure, shifting cultivation, poor road construction, landslides, improper timber harvesting, overgrazing, burning of grasslands, indiscriminate open or underground mining.

In Fiji, 70% of the land area is mountainous and 15% rolling and undulating; only 15% is flat. Most of the agriculture, mainly cultivation of sugarcane, is practised in the lowlands, although slopes up to 40^{o} are cultivated. The country has well-defined criteria for land use, e.g. arable cropping slopes up to 14^{o}, crops (except coconuts) up to 15^{o}, coconuts up to 20^{o}, grazing up to 25^{o}, and the upper limit for commercial forestry is 35^{o}. Land above this is reserved for wildlife and watershed protection. Shifting cultivation is not a major hazard. Less than 1 000 ha are cleared for staple crops on the basis of long rotations of up to 20 years. Major causes of watershed degradation are increasing population pressure, lack of adherence to the norms of land capability described above, and unscientific logging methods. There is a trend to expand the frontiers of agriculture, particularly sugarcane, onto steep slopes.

Tonga comprises 169 islands lying in an 800 km area with a total land area of 669 sq km and a population of 96 000. Agriculture is mostly subsistence, based on traditional shifting cultivation. The natural forest area shrank from almost 100% to 7% (4 960 ha) in 1953, and to 3% (2 160 ha) in 1975. The topography of the islands is gentle and the soils have good internal drainage with no evidence of runoff. Even though the island of Eua has the lowest population of the major islands, the mountainous catchment areas are endangered by excessive and indiscrimiante logging.

The Cook Islands, an archipelago of 15 islands with a total land area of only 240 sq km, are scattered over 2 million km of ocean. The islands are self-sufficient in traditional foodcrops. Many cash crops are successfully grown. (Cotton, tobacco, bananas, citrus and coffee were established export crops in 1900). Land management and production are

closely controlled by the traditional social system and there is a good knowledge of land capability. The steep slopes, high rainfall and friable soils contribute to extensive erosion, and soil loss on pineapple farms is serious.

Subsistence agriculture is the principal economic activity in Samoa. Most of the soils are deteriorating rapidly under accelerated shifting cultivation, due to an increasing population and production of cash crops for export. Taro is being increasingly planted for export and local consumption. Because of soil exposure in steep areas, and soil removal for harvesting, its cultivation is a major cause of erosion.

9.4.4 Institutional framework

All countries of Asia and the Pacific have national institutions dealing with some components of watershed management. But, with the exception of a few countries, there is no specific agency charged with overall responsibility for watershed management and rehabilitation or prevention of degradation. Seventeen countries were represented in a consultation convened by FAO in Kathmandu in 1982 to establish a regional network on watershed management. Another regional network has been set up by USAID to coordinate watershed management in the ASEAN countries.

Trained professionals must be available to undertake the survey, planning, implementation and monitoring of watershed management programmes. A survey of training and education facilities in the region shows that these are inadequate. Thailand and the Philippines are the only countries providing education in watershed management at graduate and post-graduate levels. Pakistan has facilities for training forest officers and rangers. Nepal has a rangers' college. However, training in forestry does not necessarily mean training in soil and water conservation or watershed management. The role of traditional foresters is limited to planting trees, which is assumed to be conservation in itself.

In view of the scarcity of land and the need to satisfy the demands of its growing population, the Asia and Pacific region can ill afford to bear the burden of watershed degradation and endanger its soil-water-plant production base. Many countries have adopted the "integrated watershed management" approach, which consists of reconciling the needs of the watershed population with the development potential of the forests, croplands, rangelands, wildlife, fishery and water resources, taking into account the need to protect water resources for downstream users and to protect human settlements in the watershed areas. Sometimes this integrated approach may be found in the promotion of forestry and the development of a mountain economy based on forest resources, but often the need to produce food and fodder requires intensive use of land through hillside conservation farming systems or the development of innovative systems of agroforestry and silvo-pasture management. An example of the latter approach is the Phewa Tal projet in Nepal. Diversification of the mountain economy and the development of alternative sources of income may be required when the watershed degradation hazards are too high or the population pressure too heavy.

(1) Lanly, J.P. Nature, Extent and Developmental Problems associated
1984 with Shifting Cultivation: An Overview in Report of an Expert Consultation on Education, Training and Extension for Shifting Cultivation in Developing Countries, 12-16 December 1983, Rome. Rome: FAO.

(2) FAO/UNEP. Forest Resources of Tropical Asia. Tropical Forest
1981 Resources Assessment Project. Rome: FAO.

(3) Seth, S.K. India and Sri Lanka: Agroforestry. Rome: FAO.
1981

(4) Unesco/UNEP/FAO. Tropical Forest Ecosystems: A State-of-
1978 Knowledge Report. Paris: Unesco.

(5) FAO/Unesco/WMO. World Map of Desertification. Prepared for
1977 the UN Conference on Desertification, 29 August - 9 September, 1977, Nairobi. Rome: FAO.

(6) Sheikh, M.I. Afforestation of Arid and Semi-arid Areas in Pakistan. Mimeo.

(7) Mann, H.S. et al. Land Resources Utilization in the Arid
1977 Zone: Desertification and its Control. New Delhi: ICAR.

(8) Muthana, K.D. & Kavia, Z.D. Country Statement - India.
1980 Paper presented at FAO/DANIDA Training Course on Sand Dune Stabilization, Shelterbelts and Afforestation in Dry Zones, March 1980.

(9) UNEP. Combatting Desertification in China. Nairobi.
1982

(10) UNDP/FAO. Watershed Management in Asia and the Pacific.
1983 Kathmandu, Nepal, 5-13 December 1982. Rome: FAO.

10. SOME POLLUTION PROBLEMS

Intensified agricultural production, in addition to degrading natural resources, pollutes the environment, mainly through the inappropriate use of fertilizers and pesticides.

10.1 FERTILIZER USE

Although mineral fertilizer consumption per ha of agricultural area in Asia rose 1.5 times between 1974-76 and 1983, it remains low compared to the developed countries. Average consumption was 103.6 kg of plant nutrients (NPK) per ha of arable land and permanent crops in 1983 (compared with 32.5 kg in South America, 9.7 kg in Africa, 93.6 kg in North America and 224.5 kg in Western Europe). (1) The lowest consumption per hectare was found in Lao (0.6 kg), Bhutan (1.0 kg) and Kampuchea (1.6 kg) (Annex Table 14).

With the low level of fertilizer consumption prevalent in most of Asia, there is little immediate danger of pollution. However, there are notable exceptions, such as Singapore, Korea (DPR) and the Republic of Korea, whose fertilizer consumption per ha in 1983 was 2-3 times higher than that of Western Europe, and 4-7 times higher than North America. (1) Elsewhere in Asia, consumption is increasing rapidly. The highest rate of increase between 1864 abd 1873 was ub Janoycgea (700%), followed by Lao (500%).

Excessive use, combined with inappropriate soil and crop management, could have serious detrimental effects, such as acidity or alkalinity. Undesirable environmental effects will be minimized if fertilizers are used efficiently, in combination with organic matter, where available. The correct choice of fertilizers and their application at the right time and in the required quantity are important considerations.

10.2 PESTICIDE USE

The use of chemical pesticides over the past three decades has greatly increased the yields of many crops, but over-reliance and improper use has led to pollution, increasing amounts of pesticide residues in food products, pest resistance to pesticides, and health hazards. At present there are more than a thousand active pesticide ingredients in use in a range of formulations and for different purposes throughout the world. A steady global average annual growth rate of 4.5% is foreseen (the rate of increase being greatest in developing countries), and this trend is expected to continue in spite of growing recognition of the disadvantages of excessive reliance on chemical pesticides. (2)

In 1985, the FAO Conference adopted a Code of Conduct on the Distribution and Use of Pesticides. The objectives of this Code are to set forth responsibilities and establish voluntary standards of conduct for all public and private entities engaged in the distribution and use of pesticides, particularly where there is no adequate national law to regulate pesticides. (3)

A study by the UN Economic and Social Commission for Asia and the Pacific (ESCAP) (4) estimated that US $1 000 million was spent in 13 countries in the region on the purchase of agro-pesticides during 1978 and 1980. India was by far the biggest user (US $400 million), followed by the Republic of Korea and Thailand (approx. US $120 million each), and the Philippines, Indonesia and peninsular Malaysia (US $50 to 60 million each). The 13 countries were placed in categories according to their use of pesticides (Tables 10.1 and 10.2).

Table 10.1 Total domestic supply of agro-pesticides

Country	Formulation weight	Active ingredient	Market value
	----('000 kg/litre)-----		(US $'000)
Afghanistan (1978/79)	627	323	685
Bangladesh (1978/79)	1 655	468	4 514*
Burma (1979/80)	800	360	1 926
India (1979)	250 000	50 000	400 000***
Indonesia (1978)	11 486	4 270	55 000**
Nepal (1978)	328	47	282
Pakistan (1798-79)	11 000	4 067	26 000**
Papua New Guinea (1979)	258	116	1 490
Peninsular Malaysia (1978)	21 920	5 559	52 700
Philippines (1979)	37 359	7 200	60 518
Republic of Korea (1978)	129 558	10 400	121 447
Sri Lanka (1979	5 144	1 243	12 051
Thailand (1980)	20 353	11 800	120 000***

Table 10.2 Total domestic supply per hectare

Country	Active ingredients (gramme/ha)	Value (US$/ha)
Category 1		
Afghanistan	40	0.086
Bangladesh	51	0.494*
Burma	38	0.200
Nepal	21	0.122
Category 2		
India	296	2.37***
Indonesia	261	3.36**
Pakistan	203	1.30**
Papua New Guinea	323	4.14
Category 3		
Philippines	889	7.47
Sri Lanka	579	5.62
Thailand	675	6.86***
Category 4		
Peninsular Malaysia	1 908	17.96
Republic of Korea	4 681	54.66

* Without 50% subsidy.
** c.i.f. plus ex-factory value for local formulation.
*** Estimate.

Source: Ref. (4).

Category 1: (0-100 grammes of active ingredient per ha). Afghanistan, Bangladesh, Burma and Nepal. The low level of pesticide use is due to under-developed regulatory infrastructure with no local pesticide formulation or manufacturing industry (except in the case of Nepal).

Category 2: (100-500 grammes). India, Indonesia, Pakistan and Papua New Guinea. Pakistan and Indonesia have a reasonably developed pesticide formulation industry, but depend to a large extent on imports. India, by far the largest agro-pesticide user, is almost self-supporting. Papua New Guinea has a small market and uses mainly herbicides in its crop plantations.

Category 3: (500-1 000 grammes). Philippines, Sri Lanka and Thailand have well-developed markets. The Philippines has made progress in developing its regulatory infrastructure.

Category 4: (1 000-5 000 grammes). Peninsular Malaysia and the Republic of Korea are considered to have mature agro-pesticide markets.

On the basis of these findings, a general pattern of development can be distinguished. Countries start by using traditional, cheap products in relatively small quantities. After some time, the use increases and some legislation and regulations are introduced. The range of marketed products grows to include herbicides, fungicides and modern insecticides. A local industry develops if the size of the market permits pesticide formulation and manufacture. A distribution structure develops and private retailers appear on the scene. Market growth rates naturally differ from country to country, but annual increases of about 20% are normal. Such increases, if sustained, will double total consumption every four years.

All chemical pesticides are potentially dangerous, more so to uninformed users. The World Health Organization (WHO) estimates that half a million people - mostly farmers - suffer each year from some form of pesticide poisoning. Symptoms include drowsiness, headaches, skin irritations, breathing difficulties and vomiting.

Pesticides washed into rivers become absorbed by sediment, plankton, algae, aquatic invertebrates, aquatic vegetation and fish. The accumulation of pesticides in fish can have long-term effects on their fertility and they sometimes die as a result. Examples of fish and other aquatic animals exposed to pesticides are well known in Thailand, Indonesia and Malaysia. For example, depletion of fish stocks in Malaysia's Muda River is attributed to contamination of the water by effluents emanating from a pesticides industry operating in the area. Endosulfan, used in Malaysia for the control of the rice-stem borer, is extremely toxic to the major economic species of paddyfield fish. Income from fish production can be considerable for the paddy farmer, but with the increasing use of pesticides, there is a steady decline in production from paddy areas.

The concept of "integrated pest management" (IPM - the integration of chemical control with biological, cultural and other methods), attempts to balance plant protection with environmental protection. Most countries have some IPM activities, ranging from proper use of pesticides and pest surveillance, to biological control of pests. But in no area is there a fully integrated approach. The main reasons are lack of sufficient information and trained personnel, and a tradition of following separate disciplinary activities.

Integrated pest control measures in rice, a crop cultivated under a wide range of conditions, necessarily entail considerable variation in the approaches adopted. In South and Southeast Asia, rice is cultivated in some areas using sophisticated practices and equipment, while in other areas more traditional methods are still employed. The differences in climate and physical features make it difficult to even assign names to the various types of rice cultures that exist. Transplanted, direct seeded, lowland, dryland, upland, wetland, rainfed and irrigated, are only a few of the terms used. Obviously, the pest problems occurring in these areas are diverse and complex. (5)

Rice yields have increased in nearly every country South and Southeast Asia as a result of adopting better varieties and practices. Disastrous outbreaks of pests often nullify the gains made, and it is sometimes found that, where only one insect pest was a major problem, there are now three or four. Some farmers who planted new varieties successfully for the first two or three years, have returned to the traditional varieties, as the pest problems and increased costs involved in their control were less profitable than the older methods.

A successful UNDP/FAO Rhinoceros beetle project, based on biological control techniques, operated in the South Pacific from 1964 to 1975. Previously, field sanitation had been used as a control, but was unable to suppress beetle populations which caused serious damage to coconut plantations. During the last 20 years, the beetle has been intensively studied in the South Pacific and the discovery and exploitation of a highly effective biological control agent, Rhabdionvirus oryctes, has considerably improved the prospects for copra production. (6)

In the Asia and Pacific region, a single-factor approach still tends to be used, where one aspect of cultivation is altered without sufficient concern for its effects on other aspects. Pesticides, particularly insecticides, are used without sufficient justification. In a region where pesticides are only now beginning to be used in quantity, their use should be based on sound practical information, so that maximum benefits are derived with minimal undesirable side effects.

10.3 PULP AND PAPER INDUSTRY (7)

The pulp and paper industry is a major consumer not only of wood, but also of water. Hence, its factories are normally sited near a forest with abundant water for discharging and diluting mill effluents. This can have damaging environmental effects, reducing the overall utility of forest and water resources and causing problems for wildlife protection.

Measures are being implemented to reduce both the concentration and quantity of the discharges from pulp and paper mills, although the abatement of odorous gases is still a problem because of their low threshold levels. Conventional effluent treatment systems can reduce bio-degradable wastes and suspended solids to acceptable discharge levels. In addition, reduction in water use (including closed-cycle systems), together with new production processes, should lead to less wasteful technologies. The increasing use of waste paper as a raw material is also helping conserve resources.

Because of increasing costs, the industry is seeking ways, compatible with environmental protection, of reducing energy consumption. Improving the chemical recovery process reduces both external energy use and effluent discharge. However, the introduction of pollution abatement equipment into an existing mill is costly and not always feasible, so environmental protection and resource conservation measures should be included at the design stage.

Wood pulp for the production of paper and paperboard is manufactured in several countries of Asia. Between 1977 and 1987, the capacity for paper manufacture in the developing market economies of Asia is expected to double, and to increase by about a quarter in the Centrally-planned Economies.

Pulp and paper mills in Asia and the Pacific are generally small, but many of them have no chemical recovery systems so their effluent load is sometimes comparable to much larger, modern mills. Environmental guidelines applicable to pulp and paper mills with production capacities in the range of 50 000 tonnes/year are not applicable to mills producing only 5 000 tonnes/year, where the technology and pollution load objectives are different. However, size of mill is not the only factor which determines the methodology for pollution abatement. Although one mill may not be able to carry the costs of pollution abatement, a number of small mills in the same area can share costs by having joint effluent treatment.

Although wood is the most important raw material in the production of paper, non-wood fibre sources are also used, such as bagasse, straw, tropical grasses and, sometimes bamboo. The aim of certain countries with large resources of non-wood fibre is to become as self-sufficient as possible in pulp and paper production. China, for example, relatively poor in forest resources, uses non-wood fibres as the main raw material in paper manufacture. In 1949, only 108 000 tonnes of paper and board were produced; in 1981, 5 240 000 tonnes were manufactured. In a period of 31 years, production expanded about 48.5 times, mostly from the use of non-wood fibre resources. Today, 70% of the pulp produced in China is made from non-wood fibres.

A number of problems have arisen however from the use of non-wood fibres for paper manufacture, not least of these being pollution. A major problem in the use of non-wood fibres, particularly rice straw, is the high silica content, which reduces the efficiency of recycling and waste-water treatment. Since the efficient recovery of cooking chemicals is an important requisite for pollution control, as well as for the economic running of a pulp mill, this problem has to be overcome.

As most paper production uses fibre from wood sources grown in temperate zones, most of the research and technology involving pollution control and the economic recycling of chemicals has taken place in the industrialized countries. Very little research has been undertaken to date on non-wood fibre sources. More research is needed within the context of conditions found in developing countries. Methods must be found to reduce both pollution and the cost of paper production by a more efficient recycling of the chemicals and raw materials used.

10.4 FOOD AND FEED CONTAMINATION

Environmental contamination of food is increasing in all parts of the world. Countries without effective food control systems are at a great disadvantage in securing supplies of safe food, in earning foreign exchange from food exports, and in protecting themselves from inferior food. Centralized processing and packaging runs the risk of contaminated food being distributed over wide areas.

In Asia and the Pacific, the main problems of food contamination are found in the humid and sub-humid zones, and arise mostly from contaminants of biological origin, such as parasitic infections in livestock, entrotoxin-producing staphylococci, coliform bacteria and the group of enterobacteriaceae, including salmonella. High temperature and atmos-

pheric humidity favour the development of fungi and toxic metabolites (mycotoxins). Mycotoxin contamination in the region is believed to be widespread. Limited food supplies have often forced people to accept inferior food, even if it is affected by moulds. Crops rejected for export are often sold on the domestic markets. Processing to safeguard food often raises its cost beyond the means of the people who most need it.

Suitable practices have been recommended for the prevention of mycotoxins (especially aflatoxins) in standing crops, harvesting, drying, storage, transport and processing. (8) Methods can also be used to remove, inactivate and destroy mycotoxins so that use can be made of material that would otherwise have to be rejected.

Pesticides contaminate meat (especially liver), milk and eggs in many countries. Excessive residues are often found in fruit and vegetables. Pesticides used in the region include certain chemicals that have been partially, or completely, banned for environmental or health reasons in some industrialized countries, but for which effective, cheap substitutes have not yet been developed. The direct and indirect contamination of water by pesticides may kill fish, reduce productivity or give rise to high concentrations of undesirable chemicals in edible fish tissues.

The contamination of food, feed and water by heavy metals is a serious health hazard, especially in areas having industries which produce hides and skins, batteries, textiles, ammunition, paper and fibreboard. The increasing use of canned food is resulting in contamination from lead and tin due to the use of poor-quality tinplate and lead-based solders. In many parts of the region, illegal distillation of alcohol in stills made of cheap tin material is a health hazard.

All Asian and Pacific countries have food control systems, but many need strengthening of infrastructure, training of personnel, and provision of better laboratory facilities. Legislation in many countries is is insufficient to deal with food contamination and the problems arising from modern systems of food processing.

The FAO/WHO Codex Alimentarius Commission has for many years been developing international standards for food, including maximum limits for pesticide residues and other contaminants. The Codex Coordinating Committee for Asia is active in highlighting problems of food quality and safety of special interest to the region. FAO, WHO and UNEP have developed a Joint International Food Contamination Monitoring Programme.

Biological and chemical contamination of animal feed is widespread in the region. Some serious livestock diseases arise from contaminated feed and pasture. Mixed-feed ingredients contaminated by salmonellae cause enteric diseases in slaughter animals, such as pigs and chickens.

Feedstuffs subject to contamination by _Aspergillus flavus_ (which produces the highly toxic and carcinogenic aflatoxins), include cowpeas, maize and sorghum, cottonseed, groundnut and sunflower seed cakes. An increasing health hazard is posed by the transmission of the toxin to meat, milk and eggs resulting from farm animals feeding on contaminated feed. It may also be transmitted to fish through the feedstuffs used in aquaculture.

There is no effective way of eliminating moulds from stored feedstuffs. However the control of insect infestations helps, as they often create conditions favourable to mould growth by destroying the protective hulls of feedgrain, thus exposing the moist interiors. Mould in compound feed can also be controlled, for example by using ammonia propionate.

Pesticide residues are the most common contaminants of animal feeds. Other contaminants include the newer seed disinfectants and fungicides, and certain drugs and chemicals added to feeds. Some seed treatments include organic mercury compounds, which are chemically reactive and easily absorbed.

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(1) FAO. 1985 FAO Fertilizer Yearbook 1984. Rome.

(2) FAO. 1981 Agriculture: Toward 2000. Rome.

(3) FAO. 1986 International Code of Conduct on the Distribution and Use of Pesticides. Rome.

(4) ESCAP. 1981 Comparative Study on the Supply, Distribution and Use of Agro-pesticides in the ESCAP Region. Bangkok. ARSAP/2/Agro-pesticides.

(5) Lowe, J.A. Review of Current Status of the Inter-country Programme for the Development and Application of Integrated Pest Control in Rice-Growing in South and Southeast Asia. Rome: FAO.

(5) UNDP/FAO. 1977 Research on the Control of the Coconut Palm Rhinoceros Beetle: Fiji, Tonga, Western Samoa. Review of Project Results. Rome: FAO.

(6) UNEP. 1983 Non-Wood Fibres for Pulp and Paper, in Industry and Environment, Jan-Mar. 1983, Vol. 6, No. 1. Paris.

(7) FAO/UNEP. 1979 Prevention of Mycotoxins. FAO Food and Nutrition Paper 10. Rome: FAO.

A N N E X   T A B L E S

Annex Table 1. Food and population situation in Asia and Pacific

Country	Population ('000) 1975	1984	% increase	Food production indices in 1984 (1974-76 = 100)
Bangladesh	76 582	98 464	28.6	126
Bhutan	1 157	1 388	19.9	125
Brunei	162	269	66.0	-
Burma	30 834	38 513	24.9	157
China	932 997	1 051 551	12.7	149
East Timor	672	638	- 5.1	-
Hong Kong	4 396	5 498	25.1	85
India	618 826	746 742	20.7	138
Indonesia	135 666	162 167	19.5	147
Kampuchea	7 098	7 149	0.7	99
Korea, DPR	15 853	19 630	23.8	144
Korea, Rep.	35 281	40 309	14.3	129
Lao	3 428	4 315	25.9	176
Malaysia	12 307	15 204	23.5	139
Maldives	133	173	30.1	-
Mongolia	1 444	1 851	28.2	114
Nepal	13 000	16 107	23.9	117
Pakistan	75 176	98 971	31.7	134
Philippines	42 565	53 395	25.4	132
Singapore	2 263	2 540	12.2	101
Sri Lanka	13 603	16 076	18.2	140
Thailand	41 388	50 584	22.2	140
Viet Nam	47 607	58 307	22.5	156
Sub-total	2 112 438	2 489 841	17.9	132
Fiji	576	674	17.0	156
Fr. Polynesia	132	160	21.2	-
Kiribati	54	62	14.8	-
New Caledonia	133	152	14.3	-
Papua New Guinea	2 757	3 601	30.6	123
Samoa	150	163	8.7	-
Solomon Islands	193	269	39.4	168
Tonga	88	107	21.6	100
Vanuatu	101	136	34.7	118
Sub-total	4 184	5 324	27.2	133
Total (Asia and Pacific)	2 116 622	2 495 165	17.9	132
WORLD	4 076 652	4 764 044	16.9	123

Source: FAO, 1985. FAO Production Yearbook 1984. Rome.

Annex Table 2. Soil resources in Asia and the Pacific

Country	I	II	III	IV	V	VI	VII	VIII	IX	Total
					('000 ha)					
Bangladesh	5 769	843	181	7 503	-	-	-	104	-	14 400
Bhutan	1 283	2 131	997	-	-	184	-	-	105	4 700
Brunei	126	285	-	149	-	17	-	-	-	577
Burma	19 392	30 136	6 526	8 981	1 622	288	-	710	-	67 655
Kampuchea	3 353	9 004	681	3 346	605	276	-	387	-	17 652
India	161 538	17 231	34 927	8 399	51 349	17 991	16 512	9 971	2 517	320 435
Indonesia	63 447	69 069	14 148	30 152	1 643	12 892	-	577	-	191 928
Lao	3 847	16 606	2 446	475	195	2	-	109	-	23 680
Malaysia	7 248	19 741	736	4 434	358	271	-	67	-	32 855
Nepal	6 167	1 580	3 533	1 096	-	867	-	-	837	14 080
Pakistan	9 006	154	25 905	35	77	17 712	26 202	7 136	1 451	88 678
Philippines	19 804	6 386	1 908	964	776	162	-	-	-	30 000
Singapore	5	53	-	-	-	-	-	-	-	58
Sri Lanka	3 653	1 118	639	441	44	230	-	436	-	6 561
Thailand	13 123	28 140	3 331	4 934	707	802	-	363	-	51 400
Viet Nam	6 792	17 419	2 814	4 649	523	627	-	132	-	32 956
South and Southeast Asia	324 553	219 896	98 772	75 558	57 899	52 321	42 714	19 992	4 910	897 615
China	114 028	128 882	412 162	106 897	11 797	-	78 808	31 660	53 561	937 795
Korea (DPR)	2 742	217	8 664	200	-	-	-	-	-	11 823
Korea (Rep)	1 934	2 643	4 886	385	-	-	-	-	-	9 848
Mongolia	44 670	-	55 267	304	-	-	51 078	3 813	380	155 512
Central Asia	163 374	131 742	480 979	107 786	11 797	-	129 886	35 473	53 941	1 114 978

(Continued...)

Annex Table 2. (continued)

Country	I	II	III	IV	V	VI	VII	VIII	IX	Total
					('000 ha)					
Papua New Guinea	31 617	7 401	5 273	766	-	-	-	-	-	45 057
Solomon Is.	1 752	591	80	-	-	422	-	-	-	2 845
Fiji	1 746	-	-	-	-	-	-	-	-	1 746
N.Caledonia	763	1 029	-	-	-	108	-	-	-	1 900
Tonga	51	-	-	-	-	18	-	-	-	69
Pacific Asia	35 929	9 021	5 353	766	-	548	-	-	-	51 617
TOTAL	523 856	360 659	585 104	184 110	69 696	52 869	172 600	55 465	58 851	2 064 210

Note: The 28 major soil units in the region are grouped in the following nine broad categories:

I. Soils with no serious fertility limitations (Androsols, Cambisols, Chenozems, Fluvisols, Luvisols, Kastanozems, Nitosols, Phaeozems).
II. Soils with strong fertility limitations (Acrisols, Ferralsols, Podsols).
III. Shallow soils, mostly on steep slopes (Lithosols, Rankers, Rendzinas).
IV. Poorly-drained soils (Gleysols, Histosols, Planosols).
V. Heavy-cracking clay soils (Vertisols).
VI. Coarse-textured soils (Arenosols, Regosols).
VII. Semi-desert and desert soils (Xerosols, Yermosols).
VIII. Salf-affected soils (Solonchaks, Solonetz).
IX. Miscellaneous land units (salt flats, rock debris, snow caps, shifting sand and dune).

Source: FAO/Unesco, 1978. FAO/Unesco Soil Map of the World. Vol VII: South Asia; Vol. VIII: North and Central Asia; Vol. IX: Southeast Asia; Vol. X: Australasia. Paris: Unesco.

Annex Table 3. Land use in Asia and the Pacific

Region	LAND USE				
	Arable	Permanent crops	Permanent pasture	Forests & woodland	Other
	('000 ha)				
South and Southeast Asia					
1983	259 129	15 156	35 518	326 653	208 022
% of total	30.7	1.8	4.2	38.7	24.6
1974-76	251 783	19 938	36 388	333 122	208 586
% change from '74	+2.9	-24.0	-2.4	-1.9	-0.3
Central Asia					
1983	103 027	3 637	409 472	161 543	433 322
% of total	9.3	0.3	36.9	14.5	39.0
1974-76	103 243	3 068	421 100	145 902	438 235
% change from '74	-0.2	+18.5	-2.8	+10.7	-1.1
Oceanic Asia					
1983	362	796	533	37 189	15 380
% of total	0.7	1.5	1.0	68.5	28.3
1974-76	354	770	543	37 353	15 240
% change from '74	+2.3	+3.4	-1.8	-0.4	-0.9
Total (Asia)					
1983	362 518	19 589	445 523	525 385	656 724
% of total	18.0	1.0	22.2	26.1	32.7
1974-76	355 380	23 776	458 031	416 377	662 061
% change from '74	+2.0	-17.6	-2.7	+1.7	-0.8
Total World					
1983	1 371 618	100 114	3 157 378	4 068 444	4 383 510
% of total	10.5	0.8	24.1	31.1	33.5
% change from '74	+2.3	+6.1	-0.7	-2.4	+2.1

Source: FAO, 1985. FAO Production Yearbook 1984, Rome.

Annex Table 4. Basic data for some rivers in humid tropical Asia

River	Catchment area (sq km)	Mean slope of river	Average precipitations over catchment area (mm)	Maximum flood discharge (m3/sec)	Average annual discharge (m3/sec)	Specific flood discharge (m3/sec/km2)	Average annual runoff (mm rain equiv.)	Maximum silt content (ppm)
Mekong (Vientiane)	299 000	1/2 900	1 380	23 800	4 575	-	-	3 076
Mekong (Kratie)	646 000	1/16 000	1 380	76 000	14 800	0.104	722	597
Red River (Vietri)	120 000	-	1 500	35 000	3 900	0.31	1 090	7 000
Brahmaputra								
in Tibet	293 000	-	-	-	-	-	-	-
in India	433 000	-	2 125	68 200	19 200	0.149	1 177	1 180
in Bangladesh	580 000	-	-	-	-	-	-	-
Meghna (at Bhaibab Bazar)	64 700	-	3 500	13 100	3 515	0.203	1 716	-
Ganges (at Hardinge Bridge)	976 200	-	1 250	61 200	11 610	0.063	370	1 310

Source: Aki, K. & Berthelot, R. Hydrology of Humid Tropical Asia in Natural Resources of Humid Tropical Asia. Natural Resources Research XII. Paris: Unesco. 1973.

Annex Table 5. Land area classified by growing period in Southeast Asia
(million ha)

Growing period (a) (days)	Major Climatic zones										
	1	2	3	4	5	6	7	8	9	10	Total
365 +	82.620	2.089	1.024	-	-	-	-	-	-	-	87.733
365 -	70.302	2.273	1.084	-	-	-	-	-	-	-	73.659
330 - 364	22.298	1.032	.497	-	-	-	-	-	-	-	23.827
300 - 329	48.210	1.129	.544	-	8.404	3.079	1.500	-	-	-	62.866
270 - 299	54.206	.923	.431	-	4.424	.464	.213	-	-	-	60.661
240 - 269	67.300	.496	.219	-	8.694	.945	.463	-	.119	-	78.236
210 - 239	63.078	.407	.193	-	8.992	1.396	.678	-	.163	-	74.907
180 - 209	84.956	.447	.199	-	7.888	.811	.373	-	.214	-	94.888
150 - 179	59.544	.055	.025	-	14.293	.809	.370	-	.122	-	75.218
120 - 149	53.466	.021	.010	-	16.383	.396	.181	-	.115	-	70.566
90 - 119	31.407	-	-	-	10.887	.116	.051	-	.029	-	42.490
75 - 89	9.171	-	-	-	3.780	.161	.081	-	.213	-	13.406
1 - 74	15.807	-	-	-	23.917	.030	.012	-	7.650	-	47.416
0 (dry)	5.224	-	-	-	33.844	.146	.069	-	7.287	-	46.570
0 (cold)	-	-	-	1.812	-	-	-	18.803	-	26.551	47.172
Total	667.589	8.872	4.226	1.812	141.506	8.853	3.991	18.803	15.912	26.551	897.615

(a) When rainfall greater than evaporation.

1. Warm tropics.
2. Moderately cool.
3. Cool tropics.
4. Cold tropics.
5. Warm sub-tropics (summer rainfall.
6. Moderately coool sub-tropics (summer rainfall).
7. Cool sub-tropics (summer rainfall).
8. Cold sub-tropics (summer rainfall).
9. Cool sub-tropics (winter rainfall).
10. Cold sub-tropics (winter rainfall)

Source: FAO, 1980. Report of the Agro-ecological Zones Project. Vol. 4: Results from Southeast Asia. Rome.

Annex Table 6. Land suited to the rainfed production of eleven crops in Southeast Asia (*)
(thousand ha)

Crops and major climatic zone	High inputs			Low inputs (d)		
	Very suitable land (a)	Suitable land (b)	Marginally suitable land (c)	Very suitable land	Suitable land	Marginally suitable land
1. Pearl millet (19 247)(**)						
Warm tropics	7 528	48 039	5 480	7 036	39 023	46 911
Warm sub-tropics	4 887	20 659	4 893	4 845	20 412	5 402
2. Sorghum (16 624)						
Warm tropics	36 244	60 120	30 491	11 768	45 841	51 947
Moderately-cool tropics	46	211	216	24	110	283
Warm sub-tropics	9 521	14 804	8 199	8 493	12 478	9 612
Moderately-cool sub-tropics	108	221	234	45	228	237
3. Maize (14 391)						
Warm tropics	37 878	61 682	49 557	14 609	54 496	66 670
Moderately-cool tropics	134	259	361	58	254	418
Warm sub-tropics	9 734	14 572	8 805	8 354	14 678	10 252
Moderately-cool sub-tropics	219	453	411	50	413	930
4. Wheat (25 594)						
Moderately-cool tropics	73	71	41	7	132	121
Cool tropics	39	45	28	4	70	64
Moderately-cool sub-tropics	132	360	171	122	319	245
Cool sub-tropics (summer rainfall)	67	177	87	65	158	119
Cool sub-tropics (winter rainfall)	50	43	12	51	57	16
5. Soyabean (1 062)						
Warm tropics	29 251	62 546	46 261	9 292	43 467	63 807
Warm sub-tropics	9 362	14 523	9 377	6 427	14 396	11 054
6. Phaseolus bean (9 179)						
Warm tropics	29 156	62 132	46 033	10 441	42 561	57 099
Moderately-cool tropics	66	182	298	2	129	177
Cool tropics	37	108	169	1	71	96
Warm sub-tropics	9 225	14 352	9 450	6 373	14 064	10 521
Moderately-cool sub-tropics	151	320	571	85	220	407
Cool sub-tropics (summer rainfall)	79	165	291	44	107	199
Cool sub-tropics (winter rainfall)	-	6	-	-	6	-

Continued...

Annex Table 6 (continued)

Crops and major climatic zone	High inputs: Very suitable land (a)	High inputs: Suitable land (b)	High inputs: Marginally suitable land (c)	Low inputs (d): Very suitable land	Low inputs (d): Suitable land	Low inputs (d): Marginally suitable land
7. Sweet potato (1 120)						
Warm tropics	30 202	54 514	49 883	16 119	47 303	57 871
Warm sub-tropics	11 873	13 303	6 327	9 725	14 265	8 429
8. White potato (802)						
Moderately-cool tropics	55	342	263	2	235	414
Cool tropics	32	185	148	1	127	217
Moderately-cool tropics	196	781	365	102	327	1 094
Cool sub-tropics (summer rainfall)	99	392	184	52	160	543
Cool sub-tropics (winter rainfall)	-	6	-	-	6	-
9. Cassava (2 770)						
Warm tropics	19 426	33 387	37 854	11 676	43 068	54 724
Warm sub-tropics	4 492	6 619	5 687	3 549	8 104	7 817
10. Cotton (9 704)						
Warm tropics	35 504	43 785	39 047	-	24 886	62 864
Warm sub-tropics	9 779	11 397	8 650	-	14 678	11 829
11. Rice (85 101)						
Warm tropics	-	109 025	28 707	-	51 341	52 082
Warm sub-tropics	-	13 910	2 475	-	10 283	3 500

(*) Countries covered: Bangladesh, Bhutan, Brunei, Burma, India, Indonesia, Kampuchea, Lao, Malaysia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Viet Nam.

(**) Figures in brackets give average of total area actually harvested (in thousands of ha) in above countries during the years 1974 to 1976, including rainfed and irrigated agriculture. (Source: FAO Production Yearbook 1977.)

(a) Land capable of yielding 80% or more of maximum yield.
(b) 40% to 79% of maximum yield.
(c) 20% to 39% of maximum yield.
(d) Yield basis 25% of that obtainable with high intputs.

Source: Report of the Agro-ecological Zones Project, op. cit.

Annex Table 7. Forest resources of Tropical Asia, 1980 and projections for 1985

(a) NATURAL FORESTS

Country	Broadleaved				Coniferous		Bamboo	
	Closed		Open					
	1980	1985	1980	1985	1980	1985	1980	1985
	('000 ha)							
Bangladesh	927	887	-	-	-	-	-	-
Bhutan	1 490	1 485	40	40	610	605	-	-
India	46 044	45 384	5 393	5 393	4 352	4 302	1 440	1 420
Nepal	1 610	1 210	180	180	330	310	1	1
Pakistan	860	855	295	285	1 325	1 295	-	-
Sri Lanka	1 659	1 368	-	-	-	-	-	-
Burma	31 193	30 685	-	-	116	113	632	617
Thailand	8 135	6 915	6 440	5 805	200	195	900	865
Brunei	323	298	-	-	-	-	-	-
Indonesia	113 575	110 580	3 000	2 900	320	320	-	-
Malaysia	20 995	19 721	-	-	-	-	-	-
Philippines	9 320	8 865	-	-	190	185	-	-
Kampuchea	7 150	7 025	5 100	5 075	18	18	380	380
Lao	7 560	7 060	5 215	5 040	250	250	600	600
Viet Nam	7 400	7 100	1 340	1 340	170	145	1 200	1 200
Papua New Guinea	33 710	33 600	3 945	3 940	520	520	-	-
Tropical Asia	291 951	283 038	30 948	29 998	8 406	8 259	5 153	5 083

(b) PLANTATIONS

Country	Industrial				Non-industrial			
	Hardwood		Softwood		Hardwood		Softwood	
	1980	1885	1980	1985	1980	1985	1980	1985
	('000 ha)							
Bangladesh	128	213	-	-	-	-	-	-
Bhutan	5.4	8.4	1.6	2.6	-	-	-	-
India	1 478	1 940	58	76	532	742	-	-
Nepal	3.5	5	10.3	14.8	4.9	17	-	-
Pakistan	-	-	-	-	160	195	-	-
Sri Lanka	106.4	156.4	5.6	10.6	0.3	10.3	-	-
Burma	0.5	2	-	-	15.5	15.5	-	-
Thailand	61	111	2	4	51	121	-	-
Brunei	-	-	-	2	-	-	-	-
Indonesia	1 016	1 026	430	685	305	556	167	308
Malaysia	15.1	85.1	10.9	41.4	-	-	-	-
Philippines	58	103	7	12	176	326	59	109
Kampuchea	6.3	6.3	0.3	0.3	0.2	0.2	-	-
Lao	4	5.5	-	-	7	13	-	-
Viet Nam	10	30	67	107	127	212	-	-
Papua New Guinea	3.7	4.7	13.2	17.3	4.8	8.9	-	-
Tropical Asia	2 896	3 697	606	973	1 383	2 216	226	417

Source: FAO/UNEP, 1981. Forest Resources of Tropical Asia. Tropical Forest Assessment Project. Rome: FAO.

Annex Table 8. Average annual deforestation in Tropical Asia 1976-80 and projections for 1981-85

Country	Closed broadleaved forests		Coniferous forests		Bamboo forests	
	1976-80	1981-85	1976-80	1981-85	1976-80	1981-85
	('000 ha/year)					
Bangladesh	8	8	-	-	-	-
Bhutan	1.5	1	0.5	0.5	-	-
India	132	132	11	11	4	4
Nepal	80	80	4	4	-	-
Pakistan	1	1	6	6	-	-
Sri Lanka	25	58	0.5	0.5	-	-
Burma	92	101.5	1	1	2.5	3
Thailand	325	244	-	-	7	7
Brunei	7	5	-	-	-	-
Indonesia	550	600	-	-	-	-
Malaysia	230	255	-	-	-	-
Philippines	100	90	1	1	-	-
Kampuchea	15	25	-	-	-	-
Lao	120	100	5	-	-	-
Viet Nam	60	60	5	5	-	-
Papua New Guinea	21	22	-	-	-	-
Total	1 767	1 782	35	30	13	13

Source. FAO/UNEP, 1981. Forest Resources of Tropical Asia. Tropical Forest Assessment Project. Rome: FAO.

Annex Table 9. National parks and protected areas in Asia and the Pacific

Country	Land under national parks & protected areas	Total land area	Percentage of total
	(ha)		
Bangladesh	32 386	14 400 000	0.22
Bhutan	833 700	4 700 000	17.74
China	2 273 606	959 696 000	0.24
India	11 149 261	328 759 000	3.39
Indonesia	13 755 239	190 457 000	7.22
Kampuchea	10 717	18 104 000	0.06
Korea (Rep.)	475 788	9 848 000	4.83
Malaysia	1 558 882	32 975 000	4.73
Mongolia	4 672 580	156 500 000	2.99
Nepal	974 470	14 080 000	6.92
Pakistan	6 537 311	80 394 000	8.13
Philippines	390 932	30 000 000	1.30
Singapore	2 434	58 000	4.20
Sri Lanka	642 665	6 561 000	9.80
Thailand	2 720 533	51 400 000	5.29
Viet Nam	158 068	32 956 000	0.48
Fiji	5 342	1 827 000	0.29
New Caledonia	40 161	1 906 000	2.11
Papua New Guinea	3 143	46 169 000	0.01
Samoa	2 857	286 000	1.00

Sources: IUCN, 1985. 1985 United Nations List of National Parks and Protected Areas. Gland.

FAO, 1985. FAO Production Yearbook 1984. Rome.

Annex Table 10. Permanent pasture and livestock in Asia and the Pacific Region (1983)

Country	Permanent pasture	Cattle	Sheep	Goats	Swine	Buffaloes
	('000 ha)	('000 head				)
Bangladesh	600	36 000	1 090	12 000	0	1 700
Bhutan	217	312	43	45	74	28
Brunei	6	4	0	2	15	15
Burma	361	9 338	370	951	2 734	2 049
Hong Kong	1	4	0	0	510	0
India	11 950	181 850	40 820	79 850	8 600	64 500
Indonesia	11 900	6 650	4 300	7 900	3 600	2 500
Kampuchea	580	1 247	1	1	777	510
Korea, DPR	50	1 000	330	256	2 500	0
Korea, Rep.	69	1 754	4	251	2 183	0
Lao	800	490	0	58	1 300	910
Malaysia	27	570	68	340	2 007	260
Nepal	1 786	6 980	2 500	2 560	390	4 320
Pakistan	5 000	16 157	23 531	27 716	0	12 483
Philippines	1 120	1 938	30	1 859	7 980	2 946
Singapore	4	1	0	2	1 300	2
Sri Lanka	439	1 700	29	519	77	910
Thailand	308	4 600	22	30	4 100	6 150
Viet Nam	272	1 890	18	219	10 785	2 500
South and Southeast Asia	35 489	272 485	73 156	134 559	48 925	101 783
China	285 690	57 447	106 568	75 399	305 963	18 753
Mongolia	123 663	2 396	14 955	4 802	39	0
Central Asia	409 353	59 843	121 523	80 201	306 002	18 753
Fiji	60	157	0	56	28	0
Fr. Polynesia	20	10	2	3	30	0
New Caledonia	250	100	2	8	20	0
Papua New Guinea	100	123	2	16	1 450	0
Samoa	1	26	0	0	60	0
Solomon Islands	39	23	0	0	48	0
Tonga	4	11	0	16	100	0
Vanuatu	25	100	0	8	70	0
Oceanic Asia	499	550	6	107	1 806	0
TOTAL (Asia and Pacific)	445 341	332 878	194 685	214 867	356 733	120 536
TOTAL WORLD	3 157 378	1 259 545	1 131 459	467 523	773 679	125 565

Source: FAO, 1984. FAO Production Yearbook 1983. Rome.

Annex Table 11. Freshwater and marine fish catch of Asia and the Pacific Region (1984)

Country	Freshwater	Marine	Total	Share of freshwater
	('000 tonnes)			(%)
Bangladesh	586.0	172.0	758.0	77
Bhutan	1.0	0	1.0	100
Brunei	0.1	2.7	2.8	4
Burma	143.9	442.9	585.8	25
China	2 249.7	3 677.1	5 926.8	38
East Timor	0	0	0	0
Hong Kong	6.5	193.2	199.7	3
India	1 081.9	1 777.0	2 858.9	38
Indonesia	538.0	1 679.2	2 217.2	24
Kampuchea	59.5	5.5	65.0	92
Korea DPR	100.0	1 550.0	1 650.0	6
Korea Rep.	50.1	2 427.0	2 477.1	2
Lao	20.0	0	20.0	100
Malaysia	3.8	661.2	665.0	1
Maldives	3.1	44.4	47.5	7
Mongolia	0.4	0	0.4	100
Nepal	2.1	0	2.1	100
Pakistan	70.6	308.1	378.7	19
Philippines	600.1	1 335.3	1 935.4	31
Singapore	0.4	25.1	25.5	2
Sri Lanka	30.6	140.1	170.7	18
Thailand	150.0	2 099.8	2 249.8	7
Viet Nam	220.0	545.0	765.0	29
Sub-total	5 917.8	17 085.6	23 003.4	26
Fiji	0	31.3	31.3	100
Fr. Polynesia	0	2.4	2.4	100
Kiribati	0	25.9	25.9	100
New Caledonia	0	3.5	3.5	100
Papua New Guinea	0	6.0	6.0	100
Samoa	0	3.8	3.8	100
Solomon Islands	0	49.3	49.3	100
Tonga	0	2.0	2.0	100
Vanuatu	0	2.9	2.9	100
Sub-total	0	127.1	127.1	100
TOTAL	5 917.8	17 212.7	23 130.5	26

Source: FAO, 1985. FAO Yearbook of Fishery Statistics 1984. Rome.

Annex Table 12. Regions of diversity of some crops and their wild relatives in Asia and the Pacific

1. Cereals		
Wheat	Cultivars	Central/Southwest Asia
	Wild species	Central/Southwest Asia
Rice	Cultivars	Cultivated rice (*Oriza sativa*)
	Wild species	South/Southeast Asia
Sorghum	Cultivars	India/China
Pearl millet	Cultivars	India/Pakistan
	Wild species	Asia
Barley	Cultivars	Central/Southwest Asia/Far East
	Wild species	Central/Southwest Asia
2. Food legumes		
Chickpea	Cultivars	Central/South/Southwest Asia
	Wild species	Central/Southwest Asia
Cowpea	Cultivars	Central/South/Southeast Asia/Far East
	Wild species	Asia
Faba bean	Cultivars	West Asia/India/Burma
Asiatic *Vigna*	Cultivars	South/Southeast Asia/Far East
	Wild species	South Asia
Groundnut	Cultivars	South Asia/Far East
Lentil	Cultivars	India/Pakistan
	Wild species	Southwest Asia
Phaseolus bean	Cultivars	Throughout tropics and sub-tropics
Soyabean	Cultivars	Southwest Asia/Far East/India
	Wild species	East/Southeast Asia/South Pacific
Adzuki bean	Cultivars	China/Japan
Mung bean	Cultivars	Southeast Asia
3. Other vegetables		
Chinese kale	Cultivars	China/Japan
Eggplant	Cultivars	Southeast Asia
Spinach	Cultivars	Central Asia
Rhubarb	Cultivars	Central Asia (Tibet)
Turnip	Cultivars	China/Japan
Carrot	Cultivars	Central Asia
Chinese cabbage	Cultivars	China/Japan
Cucumber	Cultivars	Central Asia
Onion	Cultivars	Central Asia
Welsh Onion	Cultivars	China
Radish	Cultivars	China/Japan
4. Root crops		
Cassava	Cultivars	South/Southeast Asia/Far East
Sweet potato	Cultivars	Pacific Islands/Southeast Asia/China
	Wild species	Throughout the tropics
5. Beverages/sweetners		
Sugarcane	Cultivars	Southeast Asia
Tea	Cultivars	South Central China/Northeast India

Continued...

Annex Table 12 (continued)

6. Condiments		
Basil	Cultivars	Southeast Asia
Black pepper	Cultivars	Malabar region of India
Cardamon	Cultivars	India
Chive	Cultivars	China/Japan
Cinnamon	Cultivars	Southeast Asia
Clove	Cultivars	Southeast Asia
Garlic	Cultivars	Central Asia
Ginseng	Cultivars	China/Japan
Nutmeg	Cultivars	Southeast Asia
7. Fruits		
Apple	Cultivars	Central Asia
Apricot	Cultivars	Southeast Asia
Banana	Cultivars	Southeast Asia
Common grape	Cultivars	Central Asia
Lemon	Cultivars	Southeast Asia
Mango	Cultivars	Northeast Asia
Sour orange	Cultivars	Southeast Asia
Sweet orange	Cultivars	South China
Peach	Cultivars	China/Japan
Pear	Cultivars	China
Chinese plum	Cultivars	China/Japan
Pomelo	Cultivars	Southeast Asia
Tangerine	Cultivars	Southeast Asia
8. Nuts		
Almond	Cultivars	Central Asia
Indian Almond	Cultivars	Southeast Asia
Chinese and water chestnuts	Cultivars	China/Japan
Coconut palm	Cultivars	Southeast Asia

Sources: FAO, 1983. Proposal for the establishment of an international genebank. Committee on Agriculture, 7th Session, 21-30 March, 1983. COAG/83/10.

Mooney, P.R., 1983. The law of the seed in Development Dialogue, 1983:1-2.

Annex Table 13. Major gene banks in Asia

Crop species	Accessions	Terms of storage	Institution/location
1. Wheat (Triticum)	20 000	Short*	CGI, Beijing, China
2. Rice (Oryza spp.)			
Common rice (O. Sativa)	60 000	Medium/long	IRRI, Los Banos, Philippines**
	30 000	Medium	IARI, New Delhi, India
	18 000	Medium/long	NIAS, Tsukuba, Japan**
	15 249	Medium	CRRI, Cuttack, India
	6 000	Medium	Institute for Agricultural Research, Bogor, Indonesia
	5 100	Medium	Rice Research Institute, Dacca, Bangladesh
	4 600	Medium/long	Koitoron Seed Bank, Penang, Malaysia
	4 227	Medium/long	Agricultural Experimentation Station, Suweon, Korea Rep.
	4 000	Short	Bangkhen Rice Stion, Bangkok, Thailand
3. Sorghum (Sorghum bicolor)	24 000	Medium*	ICRISAT, Hyderabad, India**
4. Barley (Hordeum spp)	6 025	Medium	Barley Germplasm Centre, Kurashiki, Japan
5. Millet			
Pearl (Pennisetum typhoides)	14 349	Medium*	ICRISAT, Hyderbad, India
	2 247	Short	AICMIP, Poona, India
Foxtail (Setaria italic)	5 017	Short	AICMIP, Poona, India
	3 226	Short	CGI, Beijing, China
	1 160	Medium*	ICRISAT, Hyderabad, India
Finger (Eleusine coracana)	5 904	Short	AICMIP, Poona, India
	1 241	Medium*	ICRISAT, Hyderabad, India
Kodo (Paspalum scrobiculatum)	1 405	Short	AICMIP, Poona, India
6. Roots and tubers			
Sweet potato (Ipomoea batatas)	1 200	Short	Lembaga Pusat Penelitian Pertanian, Bogor, Indonesia
	1 200	Short	Kyushu Ag. Experimentation Station, Kagoshima, Japan
	1 000	Short	AVRDC, Shanhua, Taiwan
Cassava (Manihot esculenta)	1 800	Short	Central Tuber Crop Research Institute, Kerala, India
Yams (Dioscorea spp)	7 100	Short	Dodo Creek Research Station, Honiara, Solomon Islands

Annex Table 13 (continued)

Crop species	Accessions	Terms of storage	Institution/location
7. Grain legumes			
Soybean (Glycine max)	10 000	Medium	AVRDC, Shanhua, Taiwan
	3 000	Medium	NIAS, Tsukuba, Japan
	3 000	Short	Oil-bearing Crop Institute, Wuhan, China
	2 900	Short	Shandong Agricultural Academy, Jinan, China
Mungbean (Phaseolus aureus)	5 000	Medium	AVRDC, Shanhua, Taiwan
	3 000	Short	Punjab Agricultural University, Ludhiana, India
	2 500	Short	University of the Philippines, Los Banos, Philippines
	1 000	Short	IARI, New Delhi, India
	1 000	Medium	National Plant Genetic Laboratory, Los Banos, Philippines
Chickpea (Cicer arietinum)	13 000	Medium*	ICRISAT, Hyderabad, India
Pigeonpea (Cajanus cajan)	8 850	Medium*	ICRISAT, Hyderabad, India
Groundnut (Arachis hypogaea)	8 000	Medium	ICRISAT, Hyderabad, India
Winged bean (Psophocarpus	1 000	Short	NBPGR, New Delhi, India
tetragonolobus)	1 000	Long	TISTR, Bangkok, Thailand**
	400	Long	IPB, Los Banos, Philippines

Source: Plucknett, D.L. et al. Crop germplasm conservation in developing countries, in Science, Vol. 220, 8 April 19883.

Annex Table 14. Consumption of fertilizers in Asia and the Pacific

Country	Total consumption 1983 ('000 t NPK)	Total consumption % change 1974-1983	Consumption per ha 1983 (kg NPK/ha)	Consumption per ha % change 1974-1983
Bangladesh	544.5	+ 177	59.6	+ 177
Bhutan	0.1	+ 6	1.0	- 9
Burma	159.2	+ 219	15.8	+ 216
China	1 8221.5	+ 190	180.6	+ 190
India	6 633.0	+ 133	39.4	+ 132
Indonesia	1 513.1	+ 206	74.5	+ 195
Kampuchea	4.9	+ 700	1.6	+ 700
Korea DPR	790.5	+ 70	345.2	+ 58
Korea Rep.	717.5	- 9	331.1	- 6
Lao	0.5	+ 525	0.6	+ 500
Malaysia	483.9	+ 88	111.5	+ 82
Nepal	31.9	+ 140	13.7	+ 140
Pakistan	1 200.7	+ 124	58.6	+ 115
Philippines	360.0	+ 38	32.0	+ 21
Singapore	4.7	+ 62	783.3	+ 117
Sri Lanka	161.8	+ 79	74.0	+ 69
Thailand	464.9	+ 15	24.0	+ 94
Viet Nam	357.3	+ 10	47.1	- 9
Sub-total	31 683.8	+ 147		
Fiji	10.9	- 11	46.2	- 13
Fr. Polynesia	1.0	+ 233	13.4	+ 227
New Caledonia	1.0	+ 245	100.0	+ 245
Papua New Guinea	6.8	+ 3	18.2	- 3
Sub-total	19.7	+ 2		
TOTAL	31 703.5	+ 147	193.6	+ 146

Source: FAO, 1985. FAO Fertilizer Yearbook 1984. Rome.

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